PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXIX. OCTOBER-DECEMBER, 1900. No. 164.

Stated Meeting, October 5, 1900.

Curator MORRIS in the Chair.

Present, 14 members.

Letters were read from Messrs. Cyrus Adler, Edward Patterson and Henry F. Keller, accepting membership in the Society.

The decease of the following members was announced:

John Ashhurst, Jr., M.D., on July 7, 1900.
James Biddle Leonard, on July 14, 1900.
Franklin Platt, on July 24, 1900.
Fairman Rogers, on August 22, 1900.
Sir John Bennett Lawes, on August 30, 1900.
J. M. DaCosta, M.D., on September 11, 1900.
Claudio Jannet.

The following papers were read:

By R. H. Mathews, "On the Origin, Organization and Ceremonies of the Australian Aborigines," and on "Phallic Rites and Initiation Ceremonies of the South Australian Aborigines."

By Dr. R. W. Shufeldt, on "The Osteology of the Woodpeckers."

By Charles G. Leland, on "The Old Mill of Newport."

By Perziker Karoly, on the subject of electricity.

The Society was adjourned by the presiding officer.

PROC. AMER. PHILOS. SOC. XXXIX. 164. KK. PRINTED NOV. 30, 1900.

THE ORIGIN, ORGANIZATION AND CEREMONIES OF THE AUSTRALIAN ABORIGINES.

(With Map.)

BY R. H. MATHEWS, L. S.,
CORRES. MEMB. ANTHROP. SOC., WASHINGTON.

(*Read October 5, 1900.*)

In this article it is proposed in the first place to give a short outline of the probable origin of the native tribes of Australia. Then will follow the evolution of their social laws regulating intersexual relations. A cursory reference will next be made to the initiation ceremonies, but only so far as to suggest their development. A comprehensive map will be added showing the geographic distribution of the different systems of intermarrying divisions throughout Australia, together with the boundaries within which the customs of circumcision and splitting the male urethra are in operation.

Having traveled very largely in all the Australian colonies during the last quarter of a century, in the avocation of a surveyor, as well as in grazing and mining pursuits, I have had unusual facilities for observing the customs of the aborigines, and it is hoped that the result of my researches may be found of some value for ethnographic and geographic purposes.

ORIGIN.

The origin of the aboriginal races of Australia is a subject of high and enduring interest to students of anthropology in all parts of the world; and for this reason I am tempted to submit, in as brief a form as possible, certain views at which I have arrived in regard to the peopling of the mainland of Australia and the adjacent island of Tasmania.

In attempting the solution of this difficult problem it is necessary to call in the aid of different branches of science, among which geography, comparative linguistics, zoology, botany and geology take a prominent part. Owing to the antiquity of the Australian continent, and the consequent absence of written history, it becomes necessary at the outset to propound a theory which will hold the ground, reaching far back into prehistoric times, and then to examine how this hypothesis fits in with facts observed at the present day.

It will be assumed that in a former period the physical geography of the Australian continent was different to what it is now. Geological investigations show that different portions of Australia have been under water in succession more than once, or have been alternately sea and land. The mainland of Africa and Asia at one time had a comparatively unbroken continuity southeasterly as far as Australia, Tasmania and New Guinea. Probably the extension reached farther to the south and east, but the limits mentioned will be sufficient for the present discussion. A great part of this continent—which has been called Lemuria, because it is supposed that there the lemurs had their centre of development—now lies under the Indian Ocean, but its former existence is proved by hydrographic surveys which indicate by the banks and shoals now under water where this great land was situated. Dr. Blanford has endeavored to show that it was over this lost continent that many of the older Indian animals traveled into Africa. And it is stated by Sir J. D. Hooker, the eminent botanist, that a large assemblage of blossoming plants characteristic of the Indian Peninsula are also inhabitants of tropical Australia.

The first inhabitants who were dispersed over the continent referred to were a black race of the Negroid type. They were not necessarily homogeneous, because in moving southward and eastward people of neighboring tracts of country would to some extent mix with each other by conquest or for purposes of mutual advantage, and their language and customs would be modified in certain particulars. These people form the primitive stock from which the original inhabitants of Australia, Papua and Tasmania have sprung. It is immaterial to our present purpose whether the cradle of the human race was in Asia, in Africa or in the now submerged region of Lemuria.

This primitive race spread southeasterly with comparative ease, advancing slowly because its members were not numerous and the tropical character of the country passed through made food abundant and easily obtained. It is not to be expected that the people would all keep together, or travel at the same rate. They would divide into clans or small communities, some moving on in one direction or along particular natural features—others proceeding in other directions—others perhaps remaining stationary for long periods in favorable localities. Useful arts would be developed more in some of these tribes than in others, resulting from the

character of the country occupied and their general surroundings.

Some of the southerly branches of this wave of population marched into Australia at various places on what is now the northern coast of the continent, from whence they spread over the greater part of Australia, continuing their course into Tasmania, which at that period formed one mainland, and became what may be called the autochthonous race. Northern branches of the same human stream passed into New Guinea, New Caledonia, Melanesia and Polynesia in the same way. That the race spread far and wide is evidenced by the extensive distribution of its remnants. In the speech of the present occupants of these lands traces of an original stock language can be detected. A language can adopt and create as many words as it pleases, without changing its character or altering its peculiar construction. Comparative philology must be studied side by side with comparative ethnology. Moreover, in their skeletal structure and general osteology the autochthones of Australia resemble the African negroes and Melanesians, or perhaps present a still more primitive type.

Such a migration as that outlined in the foregoing paragraphs continued for a period of prolonged duration—how long it is needless to speculate upon here. One tide of population would be succeeded by others at irregular intervals, who would naturally follow the pioneers, or advance guard, much in the same way that the settlement of countries takes place at present, detachments entering Australia at different points along the whole length of the northern coast. It may be reasonably expected that the dialects and customs of the later immigrants would differ in some respects from those of their precursors, owing to their arrival at long intervals during successive ages.

Instead of being one race, they were probably a mixture of several races of the same primitive type. It is likely that the numerical strength of a clan or family would be small, and if they kept by themselves for any considerable time the dialect of each would be modified. A number of such small clans being distributed century after century over such a large continent as Australia would account for the immense variety of different dialects we find spoken by the present inhabitants. This diversity of speech probably led to perpetual hostility and distrust among petty tribes, and so kept them separate. The existence of extensive arid tracts in many

parts of Australia necessitated migrations in search of water, and this furnishes another factor in the wide distribution of the people.

In process of time the original race was followed by hostile tribes of a more advanced type and possessing a higher degree of culture. Depressions and elevations of the land due to volcanic agencies and other disturbances of the earth's crust, and the consequent incursions of the sea, would in the interval have effected changes in the relative position of sea and land, and have completely altered the boundaries of continents and oceans. The connection between Australia, Asia, Lemuria and Africa had been more or less submerged, but there was still a comparatively uninterrupted land-route between India and Australia via Ceylon, Nicobar and Andaman Islands, Malay Peninsula, Java, Borneo, Celebes and Timor.

The second migration, like the first, would continue to march into Australia in small detached bands for a long period. In cases where the two races met and came into conflict in regard to the possession of country or otherwise, the new people, being better equipped for warfare, would subjugate the local inhabitants—the autochthonous race—and the customs, dialects and ceremonies of the latter would be assimilated or to some extent superseded by those of their conquerors. In this way most of the mainland of Australia was overrun by the invaders, but they did not reach Tasmania, because it had by that time become an island owing to the submergence of a tract of land now occupied by Bass' Strait.

There is nothing unreasonable in the assumption that these invaders and the native tribes of the southern portion of India are the descendants of a common stock—the Australians, owing to their long isolation, having retained the primitive character of their Neanderthaloid ancestors, while the later Indian tribes have attained a higher grade of evolution. Philologists have, however, failed to definitely connect the Australian tongues with the wild races of Southern India.

The Malay race, in my opinion, never invaded any part of Australia. During historic times they visited the northern coast in canoes or catamarans for the purpose of fishing for trepang, but their intercourse with the Australians was restricted to the coast and was very slight. Even if a few individuals occasionally intermarried with the Australians and went inland among the tribes, they made no deep impression either upon the race or the language.

Social Organization.

In examining the structure of Australian tribes it is found that they possess fixed laws for regulating marital relations. In some cases these laws are of a simple character and consist of the elders of the tribe alloting the progeny of certain women to be the wives of certain men; in other cases the community is segregated into *two* primary groups or phratries, the men of the one group marrying the women of the other, with a reciprocal obligation. In some tribes each of these two primary groups is bisected, making *four* intermarrying divisions. Among certain tribes of the northern portion of Australia, we find that each phratry or group is subdivided into four sections, thus making *eight* divisions of the community. These tribal divisions have been called Social Organizations or Systems, and an attempt will now be made to briefly explain their development among Australian tribes.

In portions of Australia, widely separated from each other, among which may be mentioned part of the southern coast of South Australia, part of the west coast of Western Australia and the south-eastern coastal districts of Victoria and New South Wales, we discover that the intermarriage of the individuals of a tribe is of the simple character referred to in the beginning of the last paragraph. In some respects these people differ in physical type, in weapons, in language and in their ceremonies, from the natives of other parts of Australia, but resemble in several particulars the inhabitants of Tasmania, which favors the theory already enunciated in this essay in regard to their common origin.

The old men assemble in council at irregular periods, and as often as may be necessary, for the purpose of appointing certain young married women to be what is termed *tooar* to certain boys, and such boys are likewise called *tooar* to these women. Care is taken that the parties appointed *tooar* to each other are not closely related by ties of blood. The boys are thenceforth forbidden to speak to, or even to look at, these women; and the latter are subject to a similar ban in regard to the boys. For example, if one of the women bears a daughter she gives such child, when old enough, to the young man to whom she herself is *tooar;* and if he has a sister he is supposed to give her to one of the woman's sons in exchange for his own wife. These two men would therefore stand in the mutual relationship of brothers-in-law.

A woman who is *tooar* to a man may die before she bears a daughter—or such daughter although born may die before the intended husband gets her—therefore to neutralize the chances of a man not securing a wife, more than one woman is usually appointed *tooar* to the same man. On the other hand, one woman may be appointed *tooar* to several young men. If the man to whom her daughter has been betrothed dies before he is old enough to claim her, she then becomes the wife of one of the other men. These rules may be further illustrated as follows: Lizzie, a married woman, is *tooar* to Sam, Tommy and Jack, precedence being in the order named. If Lizzie gives birth to a daughter this child will eventually become the wife of Sam. Should he, however, die before the girl reaches puberty, she would be taken by Tommy as his spouse. But if Tommy had also died then she would fall to the lot of Jack. Each of the young men named may have several married women occupying the position of *tooar* to them, to increase their chances of obtaining a wife.

An unmarried girl on attaining puberty may be assigned to the position of *tooar* in the same manner as a married woman. On her obtaining a husband her daughters eventually become the wives of the men who are entitled to claim them. This *tooar* relationship precludes the possibility of a man having sexual intercourse or any intimacy with any woman who might ultimately become his mother-in-law. A man and woman who are *tooar* to each other theoretically occupy the positions of son-in-law and mother-in-law, and the same restrictions as to mutual avoidance of each other apply in both cases alike. A man may have more than one wife, but each of them must be the daughter of a woman who is *tooar* to him. In making the *tooar* appointments the old men endeavor, as far as practicable, to arrange that the brothers and sisters in certain families shall marry the brothers and sisters in certain other families. The offspring follow the lineage of the father, and also adopt his *totem* in most cases.

In ascertaining what woman is qualified to be *tooar* to a certain boy, A, the old men, who are well acquainted with the genealogy of the people around them, know that A's father is B. They next discuss the question who are the cousins of B. These cousins, whom we shall distinguish as C, may be the offspring either of B's father's sisters, or of his mother's brothers. There will probably be several of such cousins, some in each of the lines of descent just mentioned,

from among whom the old men will select one or more to exercise the function of becoming the parent of A's future wife. Let C^1, one of the cousins of A's father, be a woman who has been thus chosen; then she is *tooar* to A, because he will by and by marry one of her daughters. The old men may also appoint the mother of A, or some other woman occupying the same position in the genealogy, to be *tooar* to the sons of C^1.

I am led to the assumption that the original or autochthonous race possessed a somewhat similar organization to that just described, and that the tribes under reference escaped subjugation by the invading races, either because the latter were not able to overcome them, or because they did not spread sufficiently far south and west as to come in contact with the original people.

In going into regions adjoining those with which I have been dealing, we encounter tribes possessing two intermarrying phratries such as Mattiri and Kararu of Port Lincoln; Krokitch and Kamatch of Western Victoria; Muckwarra and Keelparra of the Barkunjee tribes; Koolpirro and Tinnawa of the Yowerawarrika people, and so on. As I was the first author who reported the two divisions of the last mentioned tribe,[1] I shall proceed to deal with them as typical of the others.

The Yowerawarrika and allied tribes in the southeast corner of Queensland are divided, as I have before stated, into two phratries called Koolpirro and Tinnawa. The natives have told me several legends respecting ancestral warriors, and I have noticed that the most valiant and distinguished men were always said to belong to the Koolpirro division. This led me to think that Koolpirro was probably the name of a warlike tribe or clan in the remote past which had conquered the Tinnawa, an adjoining people, and that each of these tribes or clans originally possessed the *tooar* type of marriage laws.

If we assume that this was so, and that the victors followed the present practice of killing all the adult males, but sparing the women, together with the little boys and girls, the Koolpirro men, whether already married or not, would take one or more of the women of the vanquished Tinnawa tribe as wives. As the Koolpirro men would already have children by their own women, their offspring by the strange women would require to be distinguished from the

[1] *Journ. Roy. Soc. N. S. Wales*, vol. xxxiii, p. 108.

rest, and a very easy way of doing this would be to call them after their mothers, Tinnawa. When the young lads whose lives had been spared at the time of the slaughter of their fathers grew up to maturity, they would take some of their wives from among the Koolpirro women, and distinguish them by the latter name. Or in other words the Koolpirro men would give their sisters to the Tinnawa men in exchange for their sisters as wives. This would account for the origin of the two phratries Koolpirro and Tinnawa, as illustrated in the following table:

TABLE NO. 1.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Koolpirro	Tinnawa	Tinnawa
B	Tinnawa	Koolpirro	Koolpirro

Instead of the conquerors killing off all the males in the way just stated, it is customary in many places for two hostile families to make peace by the exchange of wives. This practice was much in vogue among the tribes on the Barwon river and its tributaries in New South Wales, whose customs I had exceptional opportunities of observing when stationed in those districts surveying government lands during the years from 1871 to 1880. I have also witnessed this usage among tribes in Queensland, and in the Northern Territory of South Australia.

It may be postulated that in ancient times the Koolpirro men gave their wives to the Tinnawa men in exchange for the wives of the latter, in order to terminate existing feuds, or for the purpose of resisting a common foe. A man of the Koolpirro tribe, for example, would of course have a Koolpirro wife and Koolpirro children. He would give his wife to a Tinnawa man, and her children by the new husband would be called Koolpirro the same as before. This interchange of wives might be only temporary, or it might continue during that generation. But in the rising generation the Koolpirro men would take their wives from the sisters of the Tinnawa men, and conversely the same as at present.

It is seen by Table No. 1 that the resulting offspring in both cases inherit the phratry name of their mother. They are also generally distinguished by her *totem;* thus, if the mother be an iguana, her children of both sexes will be iguanas. This rule is not universal, however, for I have found tribes possessing a dual divi-

sion on the same principle as the Yowerawarrika, where the children took the *totem* of the father.

Strength is given to the hypothesis of the coalescence of two tribes by the fact that in an adjoining community, the Barkunjee, we discover the phratry name Keelparra, evidently a dialectic modification of Koolpirro, which indicates that the tribe of that name in olden times was widespread, and perhaps powerful. Among the Barkunjee, however, Keelparra marries Muckwarra, the latter probably being the name of another vanquished or allied tribe occupying different territory, and the two phratries became Keelparra and Muckwarra.

We will now try to account for the introduction of the organization containing *four* divisions. The Warkeemon community in north-eastern Queensland, first reported by me in 1898,[1] is divided into four sections called respectively Koopungie, Karpungie, Kellungie and Cheekungie. Perhaps each of these names represented a small independent tribe or clan in former times, having the *tooar* system of relationship. To avoid repetition let us assume that Koopungie and Karpungie became incorporated either by conquest or otherwise, and intermarried on the same principle as Koolpirro and Tinnawa already dealt with. We will also suppose that Kellungie and Cheekungie amalgamated in a similar manner, and intermarried one with the other. This can be made clear by means of Tables Nos. 2 and 3, which will also show how the children were called, for distinction, by the same name as their mother in each case:

TABLE NO. 2.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Koopungie	Karpungie	Karpungie
B	Karpungie	Koopungie	Koopungie

TABLE NO. 3.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Kellungie	Cheekungie	Cheekungie
B	Cheekungie	Kellungie	Kellungie

We will now assume that the Koopungie and Karpungie confederacy (Table No. 2) subjugated the Kellungie and Cheekungie confederacy (Table No. 3); or that these two peoples thought it

[1] *Journ. Roy. Soc. N. S. Wales*, vol. xxxii, pp. 250, 251.

prudent and politic to amalgamate for the purposes of mutual defense. This alliance could have been easily accomplished by the interchange of wives between the members of the opposite confederacies. Koopungie could have taken the wife of Kellungie and could have given his own wife to a Kellungie man. Cheekungie and Karpungie could have exchanged wives in a similar manner, but there was no alteration made in the names of the offspring in any case. For example, the children of a Koopungie man were distinguished as Karpungie the same as before the coalition and so on, as in the following table, a careful perusal of which will make my meaning more clear:

TABLE NO. 4.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Koopungie	Cheekungie	Karpungie
	Kellungie	Karpungie	Cheekungie
B	Cheekungie	Koopungie	Kellungie
	Karpungie	Kellungie	Koopungie

In examining the above table, together with the two preceding ones, it will be observed that a man, Koopungie, of the A phratry in Table No. 2 marries a woman, Cheekungie, of the B phratry in Table No. 3, and *vice versa;* and that a Karpungie man of the B phratry in Table No. 2 marries a woman, Kellungie, of the A phratry in Table No. 3, and *vice versa.* It is also seen that the people belonging to the two A phratries go together, and the two B phratries together in Table No. 4. That is to say, the men of the sections Koopungie and Kellungie of the A phratry in Table No. 4 marry the women of the two sections Cheekungie and Karpungie of phratry B in this new organization, and conversely. The men and women of the respective phratries are therefore mutually related as brothers-in-law and sisters-in-law. It is therefore apparent that whether the organization consist of two divisions, as among the Yowerawarrika, or of four sections like the Warkeemon, the community still retains the two primary intermarrying phratries, A and B. Aggregates of *totems,* chosen from the fauna and the flora, are attached to each division.

It now remains to explain the probable origin of the present system of dividing a tribe into *eight* sections. If our theory is of any value it should hold good in this system as well as in that of four divisions already explained. The eight divisions of the

Wombya tribe, which I discovered and reported in the beginning of 1898,[1] will be used for illustration. The names of the sections are Choolum, Palyaringie, Cheenum, Bungaringie, Chingulum, Yacomary, Chooralum and Jamerum. We will commence with the first mentioned four of these names.

Choolum is the father of Palyaringie, and by referring back to the Yowerawarrika tribe it is seen that the children in that system take the name of the mother; therefore I shall assume that formerly the Choolum and Palyaringie clans became consolidated by conquest or otherwise, in the same way as the tribes we have been describing. A Choolum man married a Palyaringie woman, and *vice versa*, the children taking the name of the mother in both cases (Table No. 5). A similar incorporation took place between the Cheenum and Bungaringie clans (Table No. 6). Afterward these two confederacies amalgamated by interchanging their wives or sisters in the same manner as the Warkeemon people, thus transposing the intermarrying divisions, but leaving the names of the men's offspring the same (Table No. 7).

TABLE NO. 5.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Choolum	Palyaringie	Palyaringie
B	Palyaringie	Choolum	Choolum

TABLE NO. 6.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Cheenum	Bungaringie	Bungaringie
B	Bungaringie	Cheenum	Cheenum

TABLE NO. 7.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Choolum	Bungaringie	Palyaringie
	Cheenum	Palyaringie	Bungaringie
B	Bungaringie	Choolum	Cheenum
	Palyaringie	Cheenum	Choolum

We will now deal with the remaining four divisions of the Wombya tribe, namely, Chingulum, Yacomary, Chooralum and Jamerum. At the present day Chingulum is the father of Yacomary, and by again using the Yowerawarrika tribe as a basis, I will assume

[1] PROC. AMER. PHILOS. SOC., PHILADA., Vol. xxxvii, pp. 151, 152.

that in former times the Chingulum and Yacomary clans became incorporated and intermarried one with the other, the offspring being distinguished by the name of their mothers (Table No. 8). Chooralum and Jamerum were similarly coalesced (Table No. 9). Subsequently these two confederacies became amalgamated in the same way as those represented in Table No. 7, the section name of each man's children remaining unchanged. (See Table No. 10).

TABLE No. 8.

Phratry.	*Husband.*	*Wife.*	*Child.*
B	Chingulum	Yacomary	Yacomary
A	Yacomary	Chingulum	Chingulum

TABLE No. 9.

Phratry.	*Husband.*	*Wife.*	*Child.*
B	Chooralum	Jamerum	Jamerum
A	Jamerum	Chooralum	Chooralum

TABLE No. 10.

Phratry.	*Husband.*	*Wife.*	*Child.*
B	Chingulum	Jamerum	Yacomary
	Chooralum	Yacomary	Jamerum
A	Jamerum	Chingulum	Chooralum
	Yacomary	Chooralum	Chingulum

From eight separate tribes we have now illustrated the development of two communities, one represented by Table No. 7 and the other by Table No. 10, each of which has four intermarrying divisions in its social organization. At a later period these two communities, whether as the consequence of war or peace need not be considered, became consolidated into their existing form, and the course followed in arriving at this result will now be investigated.

A man of the Choolum section in Table No. 7 took the wife of a man belonging to the Jamerum section in Table No. 10; Cheenum took the wife of Yacomary; Jamerum of Table No. 10 took the wife of Cheenum in Table No. 7, and Yacomary took the wife of Choolum. All these men belong to the A phratries in their respective tribes. Again, a Chingulum man took the wife of a Bungaringie; Chooralum annexed Palyaringie's spouse; Bungaringie took Chooralum's wife and Palyaringie took the wife of Chingulum.

These four men belong to phratry B. The intermarrying sections of the new organization and those of the resulting offspring are as follows:

TABLE NO. 11.

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Choolum	Chingulum	Palyaringie
	Cheenum	Chooralum	Bungaringie
	Jamerum	Palyaringie	Chooralum
	Yacomary	Bungaringie	Chingulum
B	Chingulum	Choolum	Yacomary
	Chooralum	Cheenum	Jamerum
	Bungaringie	Yacomary	Cheenum
	Palyaringie	Jamerum	Choolum

This redistribution of the wives of the men necessarily varies the brother-in-law relationships. The men of the Choolum section in Table No. 11 exchange sisters with the men of the Chingulum section; the Cheenum men marry the sisters of the Chooralum men and *vice versa;* the Bungaringie men and the Yacomary men exchange sisters as wives; and lastly the Palyaringie and Jamerum men mutually intermarry with each other's sisters. In every case, however, the section name of each man's offspring remains as it was prior to the coalition—thus, Choolum's children are called Palyaringie the same as they appear in Table No. 7, and Palyaringie's progeny still retain the name of Choolum.

According to Table No. 11 the wife of Choolum should be a Chingulum woman, but by virtue of tribal custom he has the alternative of marrying a Chooralum. If he choose a Chingulum his children will be Palyaringie, but if he take a Chooralum wife the progeny will be Bungaringie, the section name of the offspring being regulated by the mother's division. A man of the Cheenum section, whose tabular wife is Chooralum, can marry a Palyaringie woman. In other words, the men of the pair of sections, Choolum and Cheenum, can exercise their choice of a spouse over the same two sections of women. Similar privileges are possessed by the men of the other pairs of sections, namely, Jamerum and Yacomary —Chingulum and Chooralum—and Bungaringie and Palyaringie, who can select their wives from either of the corresponding pairs of females in Table No. 11. Numbers of different totems are annexed to the divisions.

The theory of the coalition of a number of small tribes within the

area where the Wombya organization obtains is supported by the fact that in neighboring districts we discover that some of the sections appearing in Table No. 11 intermarry with others having an entirely different name, and the offspring are also differently designated. For example, in the Inchalachee tribe a Palyaringie man marries a Boonongoona, and the children are Boolangie. This could be accounted for by supposing that in former times the Palyaringie tribe became separated into two or more segments, one branch going into certain territory, whilst another branch traveled in a contrary direction, and that each branch ultimately became incorporated with different people, thus participating in the formation of diverse communities in which many of the section names are dissimilar. The same may be said of Bungaringie, who takes a Thimmemill spouse, and the progeny are Warkoo. On the Victoria river Chingulum marries a Chamaja woman and his children are Jambajunna; the wives and the offspring in each case being quite different to those in Table No. 11.

In examining the social structure of a large number of tribes, it is seen that certain section names seem to be more universal or persistent than others. For example, the name Chingulum, or its dialectic variations Jungulla, Changally, Kingulla, etc., is found in nearly every one of the tribes containing eight sections, from the Gulf of Carpentaria all the way across the Northern Territory, and extending onwards far into Western Australia. There is at the present day a tolerably numerous tribe named Chingalee who occupy a considerable tract of country between Daly waters and Newcastle waters in the Northern Territory. And although we cannot place too much reliance on the similarity of names, it is possible that this may be a remnant of the larger and more widespread nation from which the section name Chingulum has arisen.

The section name Cheenum, or its variants Jinagoo, Chanama, Chunainjah, Janna, etc., is also found among most of the communities in the country lying between the northwest corner of Queensland and Western Australia. This seems to justify the inference that at an earlier period there were, among others, two tribes called Chingulum and Cheenum, each of which were spread over an immense extent of country, and that they either conquered other tribes or were themselves subjugated, or otherwise became amalgamated with the people around them or with subsequent influxes from elsewhere, in the way I have endeavored to illustrate in prev-

ious pages, and so became scattered among a large number of different communities, as we find them at the present time.

In the foregoing pages I have endeavored to give a brief outline of the Social Organization of the Australian aborigines by tracing it through its various stages of development by means of examples taken from the marriage laws still in operation in different parts of the continent. Having studied this branch of the subject for many years, I am led to the conclusion that neither promiscuous sexual intercourse nor what has been called "communal or group marriage" has ever existed among Australian tribes. I feel equally clear that the system of divisions into sections was not devised for the purpose of preventing consanguineous marriages, but was developed in the way I have attempted to explain in this paper.

Initiation Ceremonies.

In my descriptions of the initiation ceremonies of various Australian tribes, which I have from time to time contributed to different learned societies, I have reported that there is a feigned quarrel between the fathers of the novices and the men who muster the latter out of the camp for the purpose of passing them through the ordeal of the inaugural ceremonial. I have also detailed how human blood is sprinkled upon stumps of trees; in other instances how it is collected in native vessels and eaten; and also how one or more of the men are killed to furnish a cannibalistic feast for the people present.

This has suggested to me that perhaps the ceremonies were considerably modified, if not originated, during the wars between the clans or tribes referred to in the chapter on "Social Organization." If all the adult males were killed, as at present, then it is reasonable to expect that the young captive boys would be brought up in conformity with the ancestral customs of their captors. For the purpose of doing this it would be necessary to remove them from the influence of their mothers, who would naturally cling to the customs of their forefathers and endeavor to bring up their sons with the same views.

If we investigate the procedure in the initiation ceremonies current at the present day, for an example of which the *Bora*[1] of the Kamilaroi tribe may be selected, we see that certain neighboring

[1] R. H. Mathews, "The Bora of the Kamilaroi Tribes," *Proc. Roy. Soc. Victoria*, Vol. ix, New Series, pp. 137–173.

tribes assemble at a common meeting ground and that the men of a distant tribe take charge of the novices of another people who are more or less strangers to them. We also observe that the novices are taken away from their mothers at daylight, the time that an aboriginal tribe always makes an attack on an enemy. The mothers of the boys are led to believe that an enemy really comes into the camp and bears off their sons in a mysterious manner. The women are prevented from seeing what actually takes place, owing to their being hidden under grass, bushes, rugs, bark, or other covering, but they hear what they believe to be the awful voice of the enemy and the trampling of his heavy footsteps.

In describing the Kamilaroi *Bora* I have stated that great sexual license is permitted to the men of the visiting tribes. In ordinary everyday life a man is restricted to women of a certain section or *totem*, but at meetings for initiation purposes these rules are much relaxed, and a man is allowed to have intercourse with women of different sections and degrees of affinity, who would be altogether forbidden to him on other occasions. At the *Bora* ceremonies, as soon as the novices and all their own men are out of sight, some men of the strange tribes remove the covering from off the women and take them away to another camp, where the men remain with them for the purpose of superintending the due performance of all the tribal regulations. The women are, in effect, prisoners during these proceedings.

All these elements of the ceremonial may be emblematical or commemorative of an early morning raid of one hostile tribe upon another in the distant past, one detachment of the men taking charge of the women, while another detachment takes the youths away to be instructed in the customs and traditions of their conquerors. The comparison becomes all the more realistic when we discover that during their sojourn in the bush with the old men the youths are shown many things which are entirely new to them. They are taught another language, known only to the initiated, which may be typical of the language of their subjugators; and even their own personal name is changed to another, which is kept a secret from their mothers and sisters and all the women of the tribe.

In native warfare, as already stated, the women are always preserved and taken as wives by the victorious party.[1] The sexual

[1] Several of the vanquished party usually escape by flight; they are chiefly active men, but young women often get away with them.

liberties to which I have referred probably had their archetype in the libidinous orgies which took place when a bevy of strange females was secured. The captors would make indiscriminate use of the women for some little time, until they had leisure to effect an individual distribution of them. This would take place as soon as the totems of the women and other particulars were ascertained. At the present day, when a woman is allotted to a man as his wife, she must first submit to copulation by a number of men, whose intercourse with her at other times would be a serious offense.

While the *kooringal* are marching off with the novices in their custody, two men called *buddenbelar* rush out of the scrub and each of them throws a boomerang at the aggressors. They then retreat hastily and go away to fetch the *beegay*, whose participation in the ceremony practically amounts to the rescue of the novices from the *kooringal*. This is suggestive of a time when a number of small tribes, occupying a large area, had been more or less friendly and helped each other against a common foe. If an onslaught were made upon any of these tribes such of the men who escaped would seek the protection and intervention of some of their allies who might be powerful enough to punish the offenders and liberate their sons. Such a rescue may be symbolized by the interference of the *beegay* at the present time, and the subsequent return of the novices to the *thurrawonga* camp during the *Bora*.

All the tribes who arrived in early times were probably small and lived in constant fear of surprisals by the people around them, so that it would be unwise for them to confide the details of their sacred ceremonies to the women, who might at any time be carried off by conquerors and the secrets exacted from them by coercion. This may have given rise to the existing custom of placing a covering over the women when the youths are being taken away.

It is a reasonable assumption that from the earliest period each band of adventurers brought certain rites with them. Owing to a superstitious adherence to former patriarchal customs, especially strong in all primitive peoples, we would not expect to find that any new system of initiation would altogether abrogate and supersede the older type, but would be blent or incorporated with it.

I am inclined to think that the plucking out of the hair—observed among the Narrinyeri and other tribes of South Australia, a part of the Barkunjee in New South Wales and among some of the Victorian tribes—has been handed down from the original inhabitants,

because analogous customs have been reported among Negroid people elsewhere.

As the Tasmanians have been assumed to be the remnant of the autochthonous race, some items of their initiatory customs may be mentioned. J. Bonwick, in referring to this subject, says:

"From all that I have been able to gather in my inquiries among very old residents of Van Diemen's Land it is my opinion that the custom in connexion with young-men-making [initiation] in New Holland, existed more or less with the different tribes of the Tasmanians." [1]

J. J. de la Billardiére, speaking of his visits to the Tasmanians between the years 1791–1793, says:

"We observed some in whom one of the middle teeth of the upper jaw was wanting, and others in whom both were gone."[2]

The same author says in another place:

"We were much surprised to see most of them holding the extremity of the prepuce with the left hand."

In a vocabulary appended to his work he gives the native word *loira* for powdered charcoal, with which they covered their bodies. Among many Australian tribes one or more front teeth are punched out; in others the men take hold of their genitals and exhibit them to the youths; and the smearing of their bodies with powdered charcoal and grease is widely practiced in connection with initiation ceremonies.

Speaking of the corrobories or dances of the Tasmanians, J. Backhouse[3] reports:

"In these dances the aborigines represented certain events or the manners of different animals; they had the emu dance, the thunder and lightning dance, and many others."

R. H. Davies,[4] in referring to the same subject, says:

"One is called the kangaroo dance, and is, along with some others, most violent. . . . . Some of these dances are evidently lascivious."

[1] *Daily Life and Origin of the Tasmanians* (London, 1870), p. 202.

[2] *Account of a Voyage in Search of La Pérouse* (London, 1800), Vol. ii, pp. 72 and 76.

[3] *Narrative of a Visit to the Australian Colonies* (London, 1843), p. 82.

[4] *On the Aborigines of Van Diemen's Land* (Launceston and London, 1846), Vol. ii, p. 416.

Restrictions respecting food,[1] similar in character to those in operation in Australia, have also been observed in Tasmania, some people being allowed to eat only the male, others only the female, of particular animals; whilst certain kinds of fish were forbidden to some tribes.

J. Bonwick[2] tells us of the use of the bullroarer in Tasmania: "The wise men, or doctors, ... twirled round the magic *mooyumkarr*, an oval piece of wood with a string, ... which must on no account be seen by females." He also states, at page 192 of the same work, that "circles have been recognized in the interior of Van Diemen's Land."

R. H. Davies[3] reports that when "the males arrive at the age of puberty they are deeply scarified on the shoulders, thighs and muscles of the breast."

The few references herein made to the customs of the Tasmanians have been taken from the works of early writers which were published between thirty and a hundred years ago. It is likely that the great secrecy which surrounds the celebration of inaugural rites generally had the effect of precluding the white population from witnessing or reporting what was done on such occasions.

An attempt has been made in this paper to deduce the inception of many parts of the initiation ceremonies of Australian tribes from their conflicts of the past by showing their strong resemblance to what actually takes place in internecene wars among the natives of the present day. During the long isolation of tribes, or confederacies, special characteristics have developed, and modifications have resulted in accordance with varying circumstances, among the people of different districts, until the elaborate forms of the ceremonies as we now find them have been evolved.

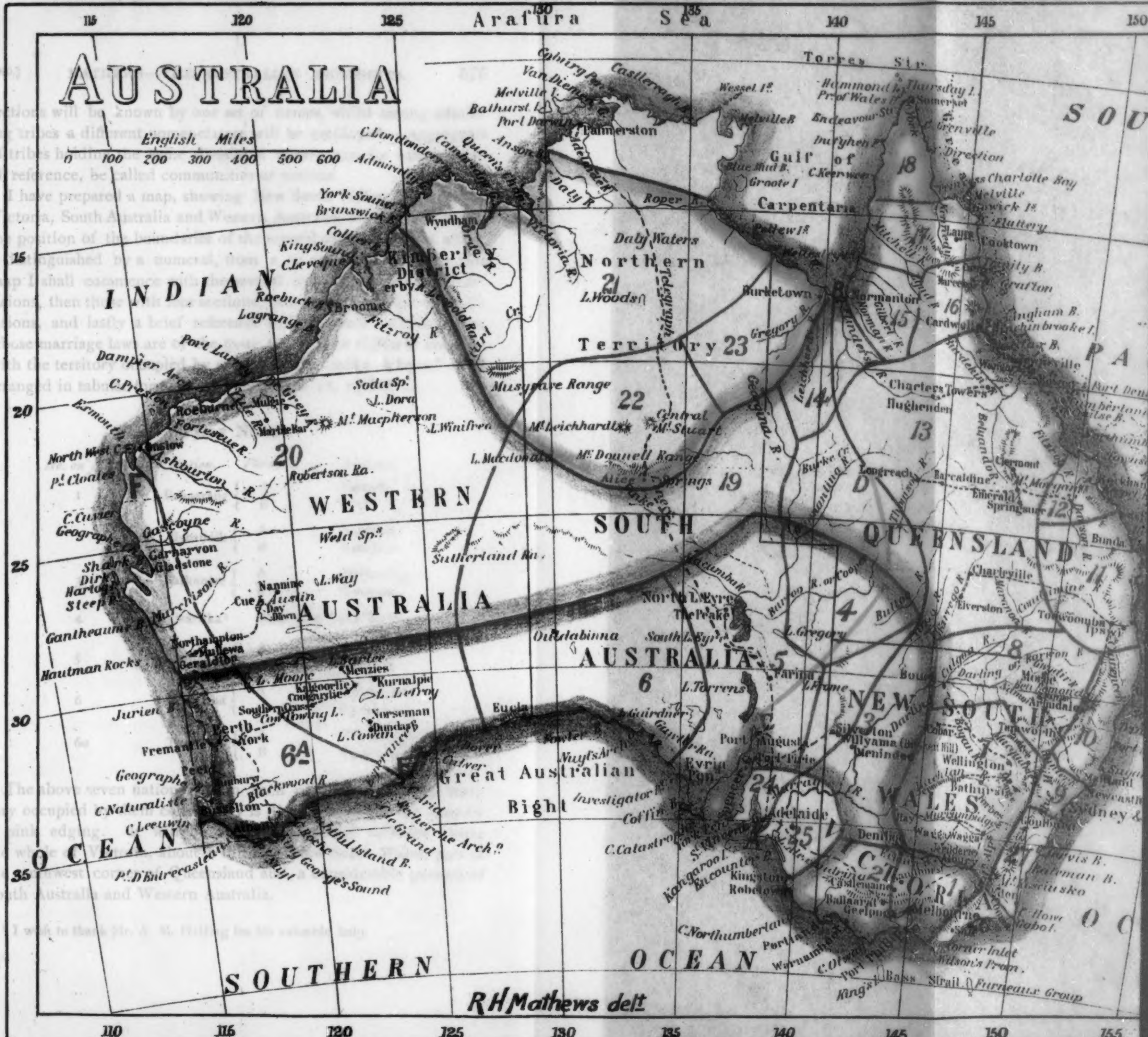
Explanation of the Map.

As already stated, a tribe is divided into sections, which are known by distinguishing titles. If we travel through any considerable extent of territory we discover that the names of these divisions vary in different districts. In a certain tract of country the

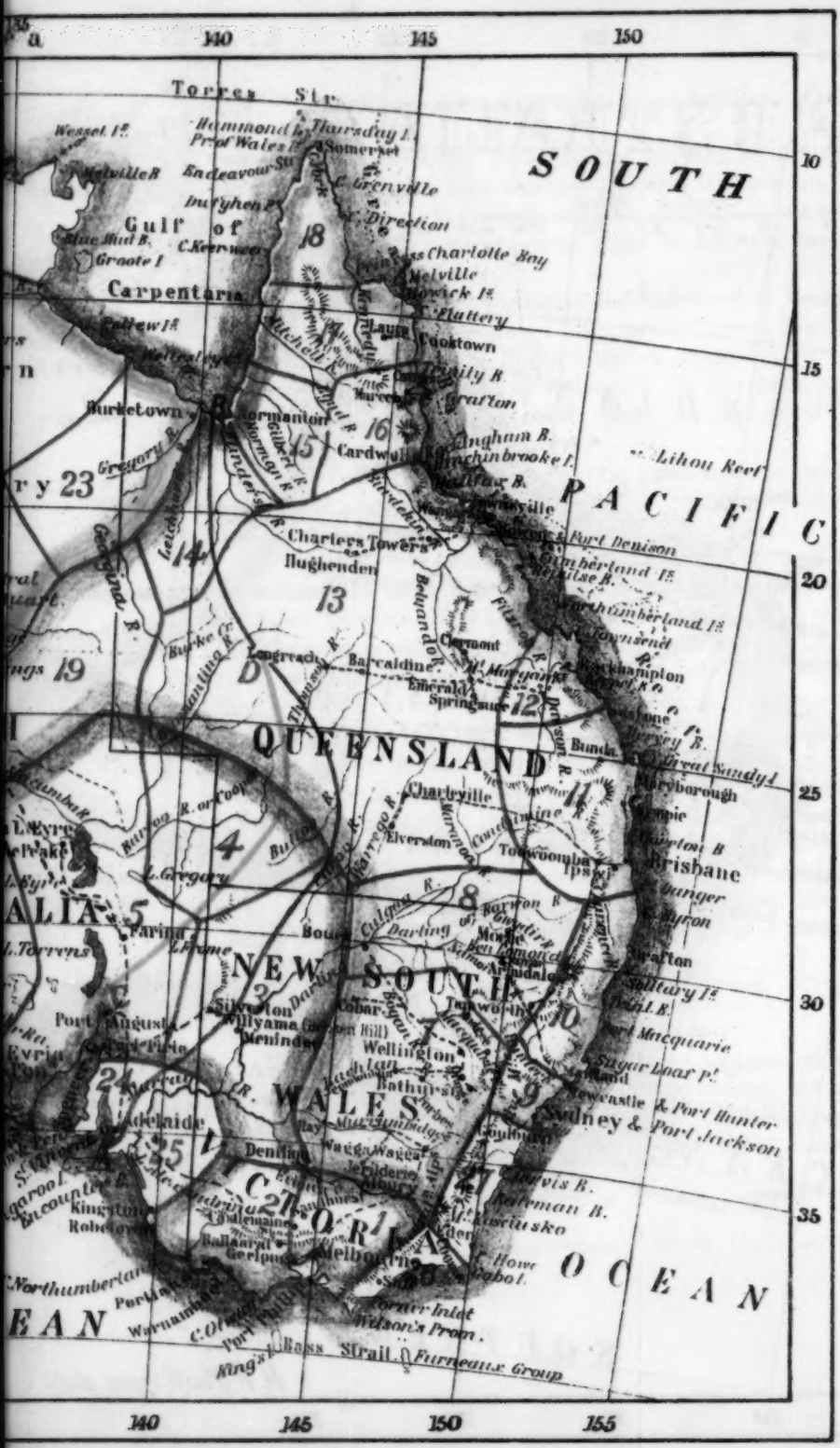
[1] J. B. Walker, *Notes on the Aborigines of Australia* (Government Printer, Tasmania, 1898), p. 9.

[2] *Daily Life and Origin of the Tasmanians* (London, 1870), pp. 175, 176.

[3] *Op. Cit.*, p. 412.



MAP SHOWING BOUNDARIES OF THE SEVERAL NATIONS OF AUSTRALIA.


135
140
145
150
155
10
15
20
25
30
35
Torres Str.
Wessel Is.
Hammond Is.
Thursday I.
Prince of Wales I.
Somerset
Melville B.
Endeavour Str.
Duryhen R.
C. Grenville
Direction
Gulf of
Carpentaria
Blue Mud B.
C. Kerr-weer
Groote I.
Port Charlotte Bay
Melville
Howick Is.
Flattery
Cape York
Cullew Is.
Mitchell R.
Laura
Cooktown
Normanton
Gilbert R.
Burketown
Morning R.
Cardwell
Gregory R.
Leichhardt R.
Boulia
Georgina R.
Burke Cr.
Landsborough R.
Thomson R.
Longreach
Barcaldine
Emerald
Springsure
Charters Towers
Hughenden
Belyando R.
Clermont
Fitzroy R.
Rockhampton
Port Denison
Cumberland Is.
Whitsunday I.
Townsend
QUEENSLAND
Bundaberg
Great Sandy I.
Maryborough
Gympie
Brisbane
Ipswich
Toowoomba
Dalby
Warrego R.
Charleville
Condamine R.
Balonne R.
Culgoa R.
Darling R.
Bourke
Barwon R.
Moree
Narrabri
Tamworth
Byron
Grafton
Solitary Is.
Port Macquarie
Sugar Loaf Pt.
Newcastle & Port Hunter
Sydney & Port Jackson
Lake Eyre
L. Gregory
L. Torrens
Flinders R.
Barrier Ra.
Darling Ra.
Broken Hill
Silverton
Willyama
Menindee
Wellington
Bathurst
Lachlan R.
Murrumbidgee R.
Goulburn
Port Augusta
Port Pirie
Adelaide
Murray R.
Murray Bridge
Wagga Wagga
Albury
Deniliquin
Kingston
Robe
Ballarat
Geelong
Melbourne
Port Phillip B.
Portland
Warrnambool
C. Otway
Western Port B.
Gabo I.
Howe
Twofold Bay
Jervis B.
Batemans B.
Ulladulla
Wilsons Prom.
Tower Inlet
Northumberland Is.
Kings I.
Bass Strait
Furneaux Group
SOUTH
PACIFIC
OCEAN
AUSTRALIA
NEW SOUTH WALES
VICTORIA
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
D

sections will be known by one set of names, whilst among adjoining tribes a different nomenclature will be employed. Aggregates of tribes holding the same divisional names may, for convenience of reference, be called communities or nations.

I have prepared a map, showing New South Wales, Queensland, Victoria, South Australia and Western Australia, on which is shown the position of the boundaries of the several nations, each of which is distinguished by a numeral, from 1 to 27. In explaining this map I shall commence with the several nations possessing two divisions, then those with four sections, next the tribes with eight divisions, and lastly a brief reference will be made to those tribes whose marriage laws are of the *tooar* type. The different systems, with the territory occupied by each, can be readily referred to if arranged in tabular form, as in Tables Nos. 12, 13 and 14.

TABLE NO. 12.

No. on Map.	*Nation.*	*Phratry.*	*Sections.*
1	Bangarang	A	Boonjil
		B	Wah
2	Booandik	A	Krokitch
		B	Kamatch
3	Barkunjee	A	Muckwarra
		B	Keelparra
4	Yowerawarrika[1]	Same as in Table No 1.	
5	Parnkalla	A	Matturri
		B	Kirraroo
6	Kookatha	A	Kookoojaba
		B	Koojeebinga
6*a*	Tardarick	A	Wartungmat
		B	Munitchmat

The above seven nations adjoin each other, and the total territory occupied by them collectively is distinguished on the map by a pink edging. It will be observed that this includes nearly the whole of Victoria, about a third of New South Wales, part of the southwest corner of Queensland and a considerable portion of South Australia and Western Australia.

[1] I wish to thank Mr. A. M. Helling for his valuable help.

TABLE NO. 13.

No. on Map.	*Nation.*	*Phratry.*	*Sections.*
7	Wiradjuri	Dilbi	Murri, Kubbi
8	Kamilaroi	Kupathin	Kumbo, Ippai
9	Darkinung		
10	Thangatty	A	Kurpoong, Marroong
		B	Wirroong, Womboong
11	Dippil	Karpeun	Barrang, Banjoora
		Deeajee	Bunda, Derwine
12	Kooinmerburra	Wootaroo	Moonal, Karilburra
		Yungaroo	Kooeealla, Koorpal
13	Kogai	Ootheroo	Woongo, Kabaroo
		Mallera	Bunburri, Koorgilla
14	Mycoolon	A	Jimalingo, Bathingo
		B	Maringo, Kooperungo
15	Goothanto	A	Erainyer, Ararer
		B	Loora, Awonger
16	Warkemon	Same as in Table No. 4.	
17	Koonjan	A	Ajeereena, Arennymung
		B	Perrynung, Mahngale
18	Joongoonjie [1]	Jamagunda	Langenam, Namegoor
		Gamanutta	Packwiky, Pamarung
19	Arrinda	A	Koomara, [2] Penunga
		B	Bultara, Parulla
20	Yeeda [3]	A	Kimbera, Bannicka
		B	Baljarra, Boorongo

It will be observed that each of the above fourteen nations is divided into four sections, and therefore all belong to the same system. The aggregate of their territory, which is edged green on

[1] My best thanks are due to Rev. N. Hey for his willing assistance.

[2] A variation of these four section names is found among the tribes on the Upper Georgina river, and extending westwards into the Northern Territory, as follows:

Phratry.	*Husband.*	*Wife.*	*Child.*
A	Belthara	Goobilla	Drungwara
	Koomara	Drungwara	Goobilla
B	Goobilla	Belthara	Koomara
	Drungwara	Koomara	Belthara

[3] This tribe inhabits the Fraser river, Derby, the Lower Fitzroy and southwards toward the Oakover river, Western Australia.

the map, comprises about two-thirds of New South Wales, the greater part of Queensland, a wide strip through the centre of South Australia and more than half of Western Australia.

In dealing with the tribes possessing eight intermarrying divisions a table will again be employed.

TABLE NO. 14.

No. on Map.	*Nation.*	*Phratry.*	*Sections.*
21	Wombya	Same as in Table No. 11.	
22	Ulperra	A	Ungarria, Thakamara
			Thaponungo, Jambena
		B	Jungulla, Thapongatee
			Joopilla, Cubadgee
23	Inchalachee	A	Boolangie, Boonongoona
			Warkoo, Thimmemill
		B	Kingulla, Bungaringie
			Noorachee, Palyaringie

The country inhabited by the three foregoing nations is edged yellow on the map, and comprises a large extent of the Northern Territory of South Australia, with portions of Queensland and Western Australia. There are several aggregates of tribes scattered over this immense area, among each of which the names of the sections differ more or less, but the principle of the divisions in them all is identical. In a paper published in the PROCEEDINGS of this Society, Vol. xxxviii, pp. 75–79, I particularized the eight divisions as found in other tribes, showing the variations in the section names in different localties.

Nos. 24 and 25 on the map represent the Adjadurah and Narrinyeri nations respectively, who occupied the country fronting Spencer's Gulf and on the Lower Murray river.

No. 26 is the small nation of the Kurnai in Eastern Victoria, and No. 27 shows the territory of the Thurrawall and allied tribes in the southeast corner of New South Wales.

In the nations Nos. 24 to 27, inclusive, the social structure is after the *tooar* or *yooumree* type already described by me. Adjoining the Great Australian Bight and on the west coast of Western Australia there are also a number of tribes possessing this organization.

After much careful investigation I have succeeded in fixing on the map the position of the blue line from A to B. All the tribes

on the west of this line practice circumcision, but in the country to the eastward of the line the custom is not in force. The line in yellow, from C to D, and continued on along the blue line to B, demarks the eastern limit of splitting the urethra—a genital mutilation having a very wide geographic range over the central and western portions of the Australian continent. The other blue line, from E to F, determines the western boundary of the tribes who practice splitting the urethra and circumcision, neither of these customs being found between that line and the coast of Western Australia. From the point F, along the coastal district to Roebourne and Condon, the rites referred to are not now insisted upon, and it is doubtful if their adoption by the natives there was ever universal.

ON THE OSTEOLOGY OF THE WOODPECKERS.

BY DR. R. W. SHUFELDT.

(Plate IX.)

(*Read October 5, 1900.*)

INTRODUCTION.

During the past ten years I have been collecting osteological material with the view of making a comparative study of the skeletons of the *Pici*, or suborder of Woodpeckers. In time this material became so extensive that I found I had all of the genera of the North American fauna represented, and had the opportunity of examining into the osteology of many other species from different parts of the world. Being advantageously situated with respect to the large libraries in America, I read and investigated everything that came to my notice upon this subject, and wrote out notes upon the same. Occasionally I printed a brief account of some of the osteological points of interest in this group as they came to hand, but the main bulk of my labors in this direction have long remained unpublished. True it is that in the *Proceedings of the Zoölogical Society of London* I printed finally (February 3, 1891) a short account of the osteological characters of the *Pici*, with a few brief notes upon the group, but this was nothing more than a partial abstract based upon what had been

accomplished up to that time. Since then all of my descriptions of the skeletology of the Woodpeckers have been gathered together, and I am inclined to believe they form the most complete history of the skeleton in those birds, both in detail and in a comparative way, that has thus far been furnished by anatomists. For making a fair and accurate copy of my collected descriptions and account of the osteology of this important group I am wholly indebted to the kind patience and intelligence of my wife, Alfhild, and it gives me great pleasure to thank her here for the assistance she has rendered.

The plates and figures illustrating the present contribution have never heretofore been published, and it is hoped that comparative anatomists will find them useful in their work.

At least three good families of Woodpeckers are known to science —that is, the *Picidæ*, the *Picumnidæ* and the *Iyngidæ*—but of these only the first-mentioned, with a variety of its genera and numerous species, is represented in the avifauna of the United States. Naturalists need not be reminded here by name of all of these forms, as the majority of them are familiar to every one. Every genus is represented by a more or less perfect skeleton in the material I have before me at the present writing, and upon which this account will be based; some skeletons I have in large series, as *Melanerpes torquatus*, of which bird I collected a large number in northwestern New Mexico in 1885. Some I have in the young stages, beautifully exhibiting the development of the skull and trunk-skeleton; others, again, are more imperfect. Thanks to the United States National Museum, I have at hand the skeleton of an Ivory-billed Woodpecker, but it unfortunately lacks the skull and some few other bones. The same institution, however, has kindly loaned me a very fair skull of *Campephilus imperialis*. Numerous skeletons of various species of the genus *Dryobates*, of my own preparation, are available, and I am indebted to Mr. Samuel Parker, of Fort Klamath, Ore., for a fine skeleton of *Xenopicus albolarvatus*. Further, I must not forget to thank my friend Mr. Thomas McIlraith, of Hamilton, Ont., Canada, for a fine skeleton of a male *Picoides arcticus*. I have skeletons in force of every one of our species of *Sphyrapicus*, all of my own collecting and preparation, and by purchase I have obtained excellent skeletons of *Ceophlæus pileatus*. Dr. W. S. Strode, of Bernadotte, Ill., has

kindly forwarded me skeletons of *Melanerpes erythrocephalus* and *M. carolinus*, and Herbert Brown, Esq., the well-known naturalist of Tucson, Ariz., has, among numerous similar favors, kindly given me the skeletons of a male and of a female *Melanerpes uropygialis*. Of the genus *Colaptes* I have a large assortment, from quarters too numerous to mention on this page. Mr. G. Frean Morcom, of Chicago, and Mr. F. Stephens have presented me with alcoholic specimens of *Dryobates scalaris lucasanus*, from Lower California.

I command few or no foreign forms, but, in addition to much other literature upon them, I have a personal copy of Prof. W. K. Parker's memoir "On the Morphology of the Skull in the Woodpeckers and Wrynecks" (1874).

With respect to the *Picidæ*, authoritative writers and ornithologists of all times seem to be of one opinion—that that family, taken in connection with the two others mentioned above, constitute a very distinct and natural group of birds with very evident passerine affinities. The American Ornithological Union considers this group to equal an order, the *Pici;* while here I treat them as one of my suborders, which likewise is designated by the same name.

Both Sundevall and Kessler recognized a separate group for the Woodpeckers (*Pici*), while Huxley's well-known characterization of them as his group, the *Celeomorphæ*, is now too well comprehended to render it necessary for me to reproduce it here (*P. Z. S.*, 1867, p. 467). At the time that that distinguished authority promulgated the opinion to which we allude he believed that the vomers in the skulls of some species of Woodpeckers remained distinct throughout life; and, further, saw the nearest affines of these birds in the Passeres (or his *Coracomorphæ*).

In the memoir of his, to which I have just alluded in a former paragraph, Prof. W. K. Parker wrote it as his opinion, in referring to the Woodpeckers as a group, that "The fact is they are like early embryos of the Passerinæ, in their palatal region arrested at a most simple Lacertian stage, whilst in other respects they are metamorphosed and specialized beyond any other kind of birds. As far as their upper face is concerned, their arrested 'maxillo-palatines,' symmetrical 'vomers,' 'septo-maxillaries' and feebly developed turbinal scrolls entitle them to a name which shall be a memorial of their Lacertian facial morphology. I therefore propose to call them the '*Saurognathæ*.'"

Garrod saw the vomer of *Gecinus viridis* in the bone which Parker designates as his "medio-palatine," and of the "vomers" of Parker, Garrod has said that "they look much more like the inner edges of the imperfectly ossified palatines." Both opinions are candid, and simply point to a difference of opinion in a matter of identity.[1]

Still another view: the distinguished ornithotomist Max Fürbringer divides his order *Coracornithes* into three suborders, of which the first is the *Pico-Passeriformes;* and these latter are again divided into three groups, the first of which is the *Pico-Passeres.* Now he subdivides the *Pico-Passeres* into the *Pici* and *Passeres,* and makes the *Pici* include *four* families, viz., the *Capitonidæ,* the *Rhamphastidæ,* the *Indicatoridæ* and the *Picidæ.*[2] The *Picidæ* here include the two subfamilies, the *Iynginæ* and the *Picinæ.* With this brief recapitulation of the opinions of former writers, I will now proceed to examine the extensive North American material before me, describe what I find in due order, and, as usual, present what it seems to indicate to me.

Of the Skull and Associated Bones in the Picidæ.

As an introduction to this part of the skeleton, I select a series of skulls taken from adult and nestling specimens of *Colaptes mexicanus.* These are very perfect and have the hyoid arches and other bones of the sense organs associated with them.

In *Colaptes* the premaxillary, slightly decurved throughout, is broad at the base and gradually tapers to its apex. It is composed of dense bone, but apparently not much more so than are the other bones of the face. On the proximal moiety of the culmen, the median suture is persistent at all ages of the bird, while laterally, upon either side, the premaxillary, assisted by the nasal, surrounds an elongated, subelliptical narial aperture of no small size. The internarial space is largely filled in by the irregular bones of the turbinal series and by an imperfect, though true, nasal septum.

[1] Compare both text and figures of Prof. Parker's memoir on the "Morphology of the Skull in the Woodpeckers and Wrynecks" (*Trans. Linn. Soc. Lond.,* read 1874) with Garrod's "Note on Some of the Cranial Peculiarities of the Woodpeckers" (*Ibid.,* 1872, pp. 357-360, and his *Coll. Scientific Memoirs,* pp. 117-119), and the figure which illustrates the latter.

[2] For the details of this classification, see his *Untersuchungen zur Morphologie und Systematik der Vögel,* published at Amsterdam in 1888.

Turning to the skull of a nestling *Colaptes*, we are to note that the frontal processes of the bone under consideration slope *gradually* up on to the frontal region about equally as far as does a nasal on either hand. This cranio-facial region is likewise *sloping* in the adult, though further on we shall see that it is quite different in some other Woodpeckers.

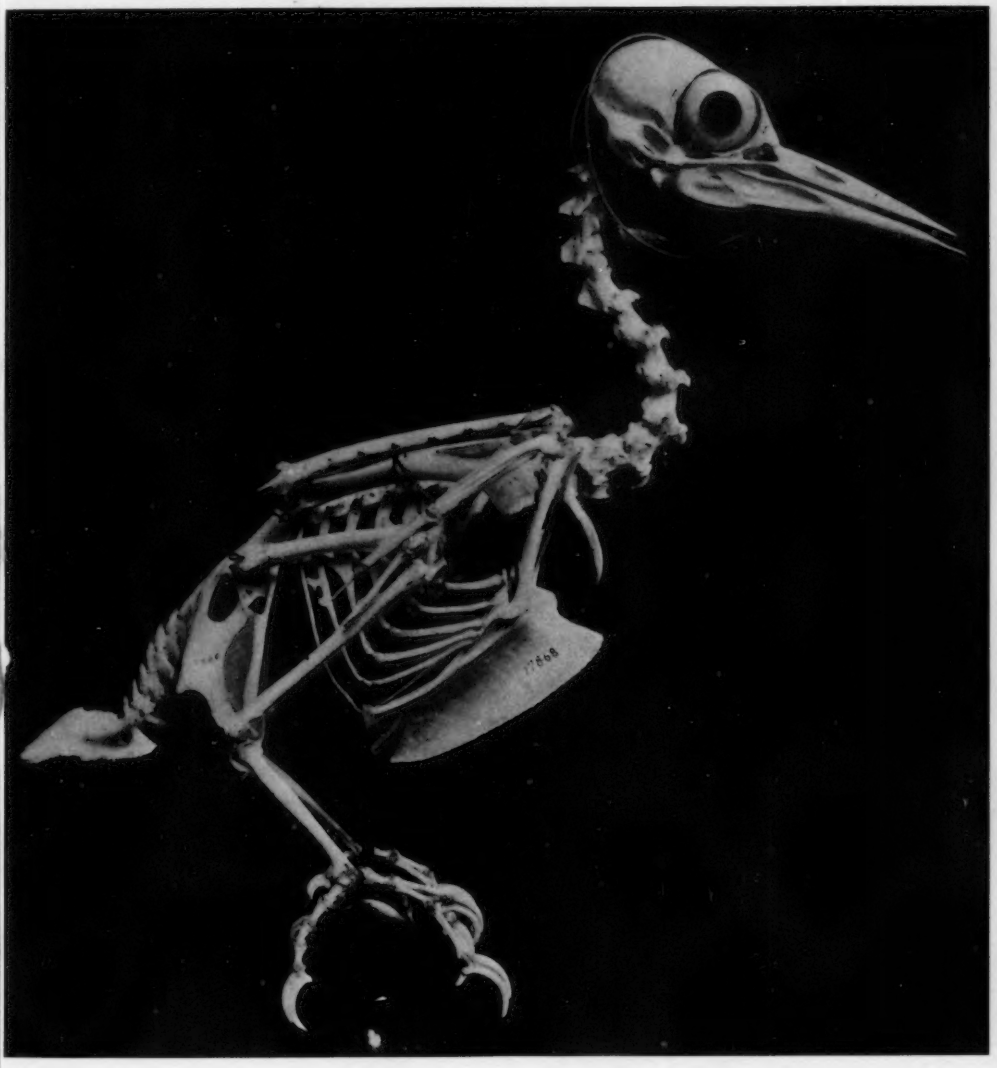
Laterally, the maxillary process of the premaxillary outerlaps the corresponding maxillary, so that in the adult, after fusion takes place, the two bones are indistinguishably united, and no suture or process thereafter marks the line of union. At the roof of the mouth, the palatine processes of the premaxillary behave in a similar manner; the prepalatine extremity being the bone that outerlaps the backward-projecting process of the premaxillary upon either side. The apex of the premaxillary in all *Picidæ* is generally a little truncated off and squarely across.

Mesially, the premaxillary unites to some extent below with the nasal septum, as we so often see it in other birds wherein that partition exists.

Nothing of especial import characterizes the frontal and parietal bones in the cranium of a nestling *Colaptes*. Essentially they agree with the corresponding bones in the immature specimen of any ordinary passerine bird—a large Thrush, for example—where the external superfices of the cranial vault is smooth and rounded.

Owing to the relatively small squamosal, however, they in *Colaptes* descend far down laterally, and this feature can easily be guessed at from a glance at any skull of an adult Woodpecker, where it will be noticed that the lateral processes of the cranium are comparatively near down toward the quadrate.

The frontals and parietals of an adult *Colaptes* do, however, possess characters not yet evident in the skull of the nestling of any of that genus. In the first place, there is the denting of nearly the entire external surface of these parial bones, which is caused by the apices of the quill-butts of the capital feathers. Again, we note in this region, in the adult, the double impressed groove, leading from the supraoccipital prominence by a gentle curve to the posterior periphery of the right narial aperture. This double gutter lodges, as we know, the free ends of the hyoidean apparatus during the life of the individual. Adult *Colaptes* also exhibit a slight tilting up of the postero-superior orbital peripheries, the margins being sharpened and a few perforating foramina occurring



RIGHT LATERAL VIEW OF THE SKELETON OF THE PILEATED WOODPECKER.
(SLIGHTLY REDUCED.)

just within their borders, one behind the other down the line. The frontal region between the rims of the orbits above is but moderately broad, and barely concaved.

A nasal bone in the skull of the young *Colaptes* has the usual form seen among the higher passerine types; it is of the holorhinal pattern, and makes the usual articulations with the surrounding bones. As the bird matures a diminutive process is seen to appear upon its posterior margin between the anterior apex of the frontal and an abutting process thrown up on the part of the corresponding maxillo-palatine. Anteriorly it sends a jagged horn of some size forward into the anterior rhinal space. A true lacrymal does not develop in *Colaptes*. The pars plana is large, very complete and of a quadrilateral outline. Postero-externally it sends backward from its angle a long, pointed os uncinatum that normally bears upon the *inner* side of the jugal bar. *Colaptes*, agreeing with all our United States *Picidæ*, exhibits considerable ossification of the turbinal series of bones, although there is a marked simplicity of the arrangement of them. One turbinal seems to be *free* upon either side, both in this and in other species. Parker has paid considerable attention to the turbinals of the *Pici*, and in briefly alluding to what he saw in other species, in the ninth edition of the *Encyclopædia Britannica* (article "Birds," p. 717), he says that "the 'inferior turbinal,' which has *three* coils in *Rhea* and *Tinamus* and *two* in most birds, is in *Gecinus* merely bi-alate; in *Junx* it makes less than a single turn, whilst the alinasal turbinal of that bird has two turns and that of *Gecinus* one. *Gecinus* is in all respects the most specialized, *Picumnus* the most embryonic and *Junx* the most passerine of the *Celeomorphæ*."

In adult specimens of *Colaptes* the interorbital septum is usually entire, though it often shows a very minute central vacuity. When we come to examine other species of Woodpeckers, later on, we will see that this foramen in them is larger and more constant.

The infraorbital bar or zygoma is made up entirely of the jugal and maxillary, the quadrato-jugal not being present. It is straight and slender, being abruptly enlarged at the posterior or jugal extremity, where it is hooked inward to articulate with the quadrate.

Nestling *Colaptes* show the development of a fine pair of orbito-sphenoids, occupying their usual sites at the back of the orbits; and within these cavities, above either orbito-sphenoid, we observe the free edge of the frontal showing its advancing ossification. At

certain points this is peculiar, as little islets of bone occur along

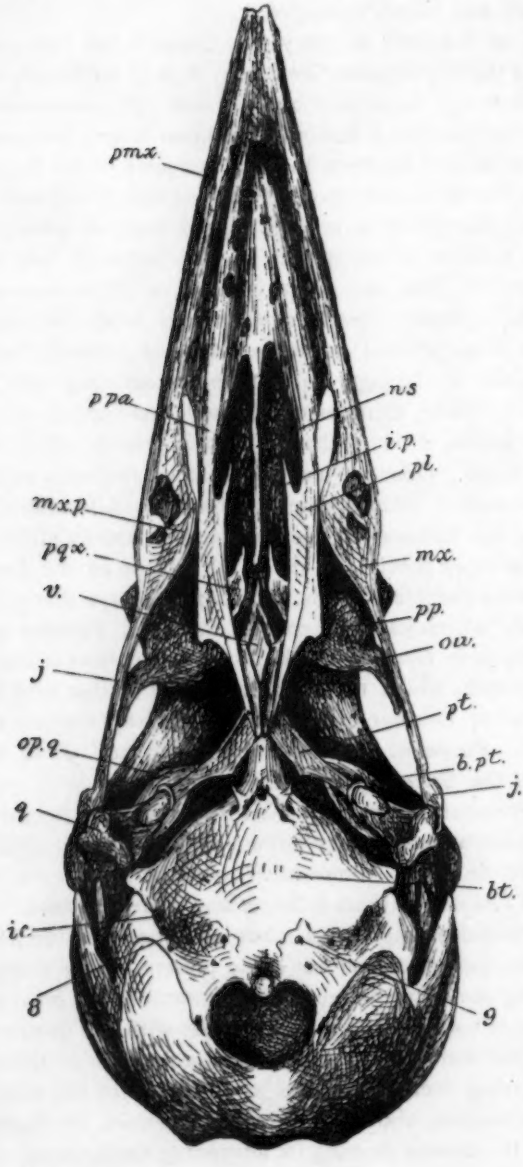


FIG. 1. Skull of adult male Pileated Woodpecker (*Ceophlœus pileatus*): under view, × 2, mandible removed. Drawn by the author. *pmx.*, premaxillary; *ppa.*, prepalatine; *mx.*, maxillary; *o. u.*, os uncinatum; *n. s.*, nasal septum; *p. p.*, pars plana; *pt.*, pterygoid; *ip.*, interpalatine spine; *j*, jugal; *bpt.*, basipterygoid process; *mxp.*, maxillo-palatine; *bt.*, basitemporal; *v*, vomer; *pl.*, palatine; *p. q. x.*, palatine spur; *q.*, quadrate; *o. p. q.*, orbital process of quadrate; *i. c.*, foramen for internal carotid artery; *v.*, foramen for vagus nerve; *g.*, foramen for hypoglossal nerve.

this free edge, which are afterward absorbed by the main bone. This process occurs in other parts of the skulls of Woodpeckers.

Passing to the base of the skull, we see a number of points of interest in *Colaptes*, and some few features that are not present in the general run of ordinary existing birds. The basitemporal region is smooth, broad and deep antero-posteriorly. Nothing especially noteworthy characterizes the large foramen magnum, with its relatively small condyle, nor the foramina in front of it upon either hand. A supraoccipital prominence is also present, being but fairly developed, and never pierced by foramina in the adult individual.

Either tympanic bulla is cowrie shaped, showing a characteristic antero-posterior slit, and, according to Parker, this unique feature of the Woodpeckers is brought about by one of these bullæ being formed by not only the corresponding exoccipital, but by two, or more often several, tympanices (usually three). The basitemporal also enters into its formation (see Fig. 1).

A quadrate is of good size comparatively, with its orbital process stout and truncated at its apex. The "mastoidal limb" is short, and the mandibular facets peculiar. Either pterygoid is noted for its pointed and lengthened meso-pterygoid, which, when *in situ*, reaches forward to the palatine spur of the same side. On the upper edge of a pterygoid a prominent and pointed muscular process is developed; it has the same direction forward and inward as has the shaft of the bone. This shaft is thin and much compressed, while the quadratal head is small and inconspicuous. When articulated, the palatal heads do not meet mesially, or they may just barely touch each other. Occasionally we find in old specimens of *Colaptes* minute osseous "prickles" at the usual sites of the basipterygoidal processes, and they represent aborted basipterygoids. They are more prominent in certain other Woodpeckers of our avifauna, but it is only rarely that the corresponding process is ever seen upon the pterygoid. It is present, though very rudimentary, in a specimen of the Pileated Woodpecker before me.

The inferior border of the rostrum is rounded and not very thick transversely. It is very sharp in front, and below is usually carried out as a little spine. Either palatine is narrow, especially anteriorly beyond the maxillo-palatine, or what is known as its *prepalatine portion*. Distally this extremity is underlapped by the palatine process (of the same side) of the premaxillary. Poste-

riorly the postero-external angle is obliquely truncated, and the head for the corresponding pterygoid is completely aborted, the palatine being simply drawn out at this end. About midway up its mesial border it develops a conspicuous interpalatine process, directed forward, while another free process, also directed forward, springs from that point on the bone where the bifurcation of the vomer articulates in a great number of ordinary birds. This last process, so variable and so conspicuous in nearly all *Pici*, I here designate as the *palatine spur*. During ossification of the mesial and external margins of either prepalatine minute islets of bone are left, and these may persist or they may not persist during the life of the individual.

The vomer, mesial in position, is situated rather far back between the palatines, and is non-bifurcated posteriorly. It is pointed in front and pointed behind, and rests for nearly its entire length upon the nether aspect of the sphenoidal rostrum. In some Woodpeckers it is quite compressed in the vertical direction and of somewhat of a lozenge-shaped outline. That it is not forked posteriorly need not surprise us, for that also is the case with the semi-rudimentary vomer in *Geococcyx* and some other birds.

The lower margin of the mid-lying nasal septum is long and scraggly; while above, the laminated portion of the bone is not completed up to the premaxilline roof. A maxillo-palatine is of considerable size, broad, horizontally flattened, perforated upon its nether side by foramina, and finally it sends backward from its mesio-posterior angle a blunt-like process. This last feature is absent in many *Pici*, and here in *Colaptes* the inner margin of a maxillo-palatine barely comes in so far as the outer border of the corresponding palatine, and so these bones are widely separated from each other in the middle line.

In *Colaptes* the mandible is of the typical V-shaped pattern, long and narrow, with a very shallow symphysis. Its ramal sides are rather shallow, upright and with rounded superior and inferior borders. A ramal vacuity is absent, or reduced to a mere pinhole or smaller. The angular extremities are rounded, and offer no special process on either side. This jawbone is pneumatic, and its hinder articular ends present the usual ornithic characters, with perhaps an arrangement of the mandibular facets peculiar to the *Pici*, but departing but little from what we find in almost all ordinary avian types. In the adult all the sutural traces among the splint-bones composing the mandible have disappeared.

A very curious condition of the sclerotal plates of the eyeball exists in *Colaptes* and all other American *Pici* wherein I have examined them. These plates very thoroughly fuse together, although in the nestling at the time it leaves the nest they are still separate. In the case of the sclerotals of a specimen of the big Imperial Woodpecker before me this fusion is so perfect that all the sutural traces among the plates have well-nigh disappeared entirely. Such a condition is not common among highly organized birds.

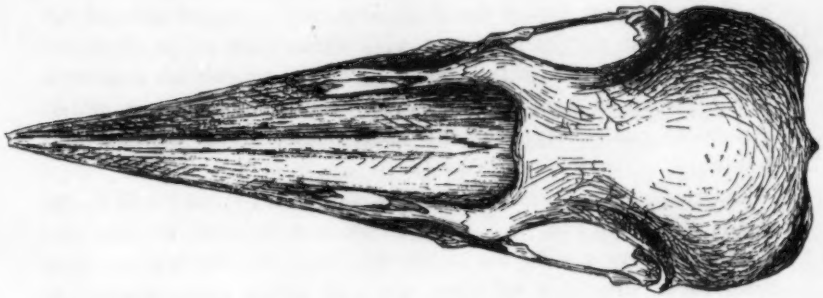


FIG. 2. Superior view, natural size, of the skull of the Imperial Woodpecker (*C. imperialis*). Drawn by the author from specimen No. 1464 of the osteological collections of the United States National Museum.

The present writer has not paid any very special attention to the bones of the ear in the *Pici*, but Parker has said of them for *Gecinus viridis* that "The stapedial apex of the largely aborted second postoral arch has some peculiarities of importance. The *true* stapedial or periotic portion is rather large and roughly oval, the side toward the 'opisthotic' bar separating the fenestra ovalis from the fenestra rotunda being straightest.

"The *capitular* portion of the arch, continuously ossified with the base, is the flattish 'medio-stapedial'; a bony rod from this bar runs down the anterior 'infrastapedial' bar, bringing to mind the small bone in the 'stapedius' muscle of the mammal; it is its *symmorph*. This double 'infrastapedial' is new to me; it ends below in a spatulate stylohyal, which has a proximal ossicle just below the infrastapedial fenestra. The extrastapedial is falcate and broad-backed; the 'suprastapedial' is small; and from it and from the proximal end of the extrastapedial a fibrous fan arises, which supplements the small 'tubercular' head of this facial rod. The

proximal portion of the large 'stapedial fenestra' is hidden in this view; but it scoops the falcate 'extrastapedial' beneath its thick outer or back part" (*Trans. Linn. Soc.*, read 1874, p. 10).

Passing to the *hyoidean apparatus* of *Colaptes*, we are to observe that the epibranchials of the thyrohyals are exceedingly slender rods of bone, and have their extremities resting just within the posterior periphery of the right external nostril.

In specimens before me the *left* epibranchial is several millimetres longer than the right. From this point they lie along in the groove on top of the skull, and curving round behind the cranium, join similar-fashioned ceratobranchials at points about opposite the position of the vomer. The ceratohyals are small and fuse together to form a delicate arrowhead-shaped bone, which articulates posteriorly with the long, single, highly ossified basibranchial. There is no urohyal.

Other *Pici* have the epibranchials curl round the orbit as in the genus *Picus* (see Fig. 6). We are now in a position to make certain comparisons with the skulls of other *Pici*, comparing them with those structures we have just had under consideration in *Colaptes*, and first let us take up the skulls in certain species of *Melanerpes*.

Melanerpes torquatus (Lewis's Woodpecker) offers us some wonderfully interesting differences. It possesses a comparatively broad skull, with ample brain-case, which latter is externally rounded and smooth. In the frontal region it is rather broad between the superior orbital peripheries. The grooves for the ends of the hyoid are very shallow, barely perceptible, and then only occur no farther forward than the postfrontal region. At the cranio-facial hinge, which is directly transverse, the frontals very slightly roll over on the nasals and the premaxillary. This remarkable picine character is far more distinct in other genera. We find the interorbital septum absolutely entire in the adult, while a very ample quadriform pars plana is seen, but a distinct os uncinatum does not appear to be present, and the angle where it occurs is not especially produced.

Although the tympanic bullæ are somewhat cowrie-shell shaped, they are by no means so conspicuously so as they are in *Colaptes* and some other forms. The basipterygoidal processes are notably rudimentary, and hardly to be seen in some skulls of this species. Picine in their general pattern, the pterygoids show but a compara-

tively reduced process on either one for muscular attachment, and when articulated *in situ* they are seen to touch in the median line.

Either palatine has its internal and external laminæ rather more curled downward as compared with the thin, horizontally flattened bones of *Colaptes*. The postero-external angle in each develops a definite process, which is directed backward. Individuals vary with respect to the lengths of the palatine spurs, they being markedly longer in some than in others, but *their anterior ends are always free* in this species. Inner and outer borders of the palatines are *not* ragged, but very smooth and straight, inclining one to believe that the ossification along them is different from what I described for *Colaptes*. A free turbinal is found in either rhinal chamber. The maxillo-palatines are very much reduced, and strikingly narrow transversely, while the vomer appears to be absent. I examined seven specimens to satisfy myself of this latter fact. The posterior reduced ends of the hyoidean apparatus only reach up to the vault of the cranium; they are very elastic even in the long dried skeleton, and moreover they are *flattened* in the vertical direction.

In the mandible the symphysis is relatively deeper than we found it in *Colaptes*, and the foramen in either ramus a little larger.[1]

Our Red-headed Woodpecker (*M. erythrocephalus*) essentially repeats what we have just described above for *M. torquatus*. In 1879 I collected an old male of this species at Fort Fetterman, Wyo., and its skeleton is now at hand; since then several specimens have been presented me, and chiefly by Dr. Strode, of Bernadotte, Ill., to whom my thanks are due for them.

A vacuity may or may not exist in the interorbital septum of the Red-headed Woodpecker, and at the cranio-facial hinge the rolling forward of the frontals is not nearly so evident. The ends of the hyoid come higher up on the skull, reaching as far forward as the mid-point between the orbits. The muscular process on either pterygoid is purely rudimentary, and I fail to find a lacrymal in any of this genus. No vomer is developed, but in a specimen before me the beak of the rostrum supports a curious hairlike spine extending forward in the middle line for several millimetres. In

[1] I am not quite confident that the ramal vacuity we find in the jaws of *Colaptes*, *Melanerpes* and the Imperial Woodpecker corresponds with the true ramal foramen as seen in other birds (Passeres). Careful comparisons rather incline me to think that it does not.

the mandible the posterior angular process is inclined to be slightly more produced.

Superficially, the skull of *Melanerpes uropygialis* almost resembles that of some of our more delicately structured Thrushes.[1] All the bones composing it are notably thin and semi-transparent, more especially those of the brain-case and frontal region. There is an os uncinatum present, while the interorbital septum is, as a rule, entire. The lower border of the nasal septum ossifies, and the anterior border of the external narial aperture is curled inward to meet the same of the opposite side. Mesially, these coössify and form a transverse partition at the point in question. Viewing this skull from above, we find the cranio-facial region much as it exists in *Colaptes*—that is, the frontals do not bulge over the ends of the premaxillary. None of the birds in this genus seem to have the external vault of the cranium dented by the butts of the quills of the capital feathers, and the ends of the hyoid rarely reach so far forward as the mid-point of the frontal space between the superior margins of the orbits. In this Gila Woodpecker we find the palatines much the same as they exist in *M. torquatus*, and the same remark applies to its mandible and hyoidean apparatus.

Melanerpes carolinus has the skull and associated parts very much like the corresponding structures in *M. uropygialis*, though, nevertheless, it has a specific *facies* of its own—a *facies*, however, that would compel the comparative osteologist to sink to insignificant details to define. But, exasperating as this puzzling intergradation is among the skeletons of these Woodpeckers, it is an exceedingly interesting picture to take in by the eye.

In *M. carolinus* the tympanic bullæ are so reduced as hardly to call to mind the cowrie-shell-shaped cavity at all, and the 'slit' is comparatively wide. We find in this skull also that the postero-external angles of the palatines to be *rounded* off, thus differing markedly with *M. torquatus* in this particular. No vomer is present. Maxillo-palatines are very narrow, and an os uncinatum seems to be absent. *M. aurifrons* has also been examined, but requires no special comment.[2]

I have also examined skulls of the Narrow-fronted and California

[1] Owing to the kindness of my friend Mr. Herbert Brown, of Tucson, Ariz., I have skeletons of both male and female specimens of this species.

[2] I am indebted to Mr. F. Stephens for several specimens of this species.

Woodpeckers of this genus, and they all present essentially the main cranial characters alike.

FIG. 3. Right lateral view, life size, of the skull of the Imperial Woodpecker mandible removed; same specimen as shown in Fig. 2.

Ceophlœus pileatus is a very large Woodpecker, and the sole represenative of its genus in this country. Its skull and associated parts present us with a number of characters of interest, some of which are different from those discussed in *Colaptes* and *Melanerpes* (see Fig. 1). Two skeletons of this pileated Woodpecker are before me, and both are from adult males. One of them has a skull eight centimetres long by nearly three centimetres wide at its widest part over the quadrates. Viewing it from above, we are struck by the great width of the superior osseous mandible, especially at its base. This part of the skull is much compressed from above downward—a fact which has its due effect upon the form of the external narial apertures. The frontal region slopes gradually down upon the premaxillary over the cranio-facial hinge. As in *Colaptes*, the gutters for the accommodation of the ends of the hyoid are very distinct, and that apparatus passes to the right nostril, as in the form we have just mentioned. For the rest, on this aspect of the skull in the Pileated Woodpecker, we find a handsomely rounded cranial case, which is pitted all over the parietal and postfrontal regions in a manner already noted for other forms above. Looked at from behind, we note a well-marked supra-occipital prominence, while farther along, on either hand, the tympanic bullæ are unusually well developed, having the picine character of these parts brought up to their comparative maximum size. Coming to the infraorbital bar, we find it composed only of the jugal and maxillary, the two forming a straight, stout rod, which is laterally compressed, and enlarged and hooked at its

proximal end. The interorbital septum exhibits a rather large subelliptical vacuity at its centre. Pars plana is large and thick through antero-posteriorly; its lower outer angle is produced backward by a long os uncinatum. Rudimentary basipterygoidal processes are present, and the corresponding vestigeal apophyses are to be seen upon either pterygoid. Otherwise these latter are much as we find in the *Pici* generally, the hooks for muscular attachment being well produced. Mesially, between the palatine a large vomer is seen to be present; it has the form of a spear-head, with its anterior angle produced forward as a delicate spine. Turning to a palatine bone, we find it narrow and straight, and of nearly equal width throughout. Its postero-external angle is bluntly produced, while behind it makes the usual picine articulation with the pterygoid of its own side. The palatine spur is *short*, freely pointed in front and appears more as an outwardly curled part of the palatine lamina proper. It is curious in possessing a distinctly produced process upon its outer aspect near the middle. This form of the palatine spur is quite different from that of any other Woodpecker that I have ever examined. Running forward from the apex of the interpalatine spine there is a ragged string of subossified tissue that is again anchored in front to the mesial border of the bone. In this structure we may find several islets, of an elongated form, of true bone. I consider them to be, as I do in other species already mentioned, detached parts of the prepalatine, which is but poorly ossified along the border in question. This imperfect mode of ossification is extended to the mesial subnaso-septal bar, which we here find to be composed of the same subosseous tissue containing elongated granules of true bone. Detached turbinals are found in the narial chambers of the Pileated Woodpecker, but these parts seem to depart but little from what has already been described for other picine types.

There is a special character that should be noted in the skull of *Ceophlæus*, and it is the *raised* osseous line that runs mesially down the column of the premaxillary. This character is well seen in the Imperial Woodpecker also, but is absent in representatives of the genus *Colaptes* and *Melanerpes*.

Our Pileated Woodpecker has a very strong mandible, of a form usually seen among birds of this group. Posteriorly the ramus is deep in the vertical direction, and the downwardly convexed border below is here much roughened, a character it exhibits in com-

mon with the Imperial Woodpecker (see Fig. 4). Imperfect as the skull of the individual of this latter species is that I have for examination, it yet presents us with a number of very important characters.[1] Upon superior aspect, this skull has the general characters of the skull of a Pileated Woodpecker; it differs, however, in having the bones of the frontal region to some extent bulging over the broad superior base of the premaxillary (see Fig. 4). Relatively the vault of the cranium in *C. pileatus* is higher

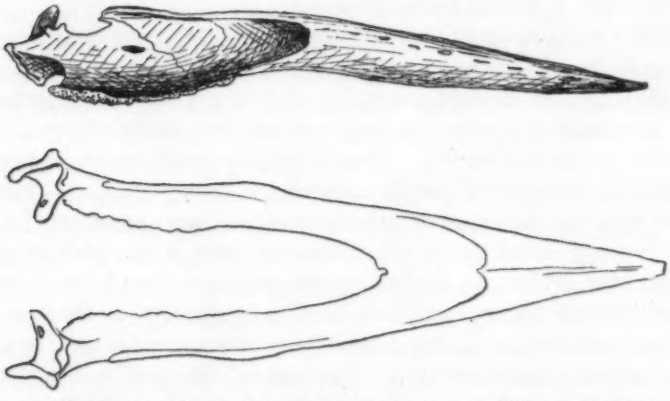


FIG. 4. (Upper one.) Right lateral aspect of the mandible of the Imperial Woodpecker.

FIG. 5. (Lower one.) Superior view of the same bone and in outline. Both figures natural size and drawn by the author from the mandible belonging to the skull shown in figure 2.

and more rounded than it is found to be in the Imperial Woodpecker; in other words, the brain-case, and consequently the contained cephalic mass, is larger in the first-mentioned species than it is in the last. I have not the skull of an Ivory-billed Woodpecker at present for examination, but am inclined to believe that it will be found to resemble the skull we now have under consideration, and its chief points of difference with what we found in the skull of *C. pileatus* are seen to refer to the palatine bone. This

[1] The specimen belongs to the collections of the United States National Museum (No. 1464). It lacks the pterygoids and hyoidean arches, and I am inclined to believe that the vomer has also been lost. The collector, however, preserved the sclerotals of one eye, and it is remarkable to see how completely they are fused into one circlet of bone.

element is most remarkably modified, for, in the first place, it is comparatively very narrow, being nearly of an equal width throughout, while its postero-external angle is completely rounded off. Then, again, the palatine spur starts from the palatine proper (at the usual site), first as a delicate, half-turned whorl of bone, which is extended *directly* forward as a *fine* osseous thread fully two centimetres long. The anterior end of this latter coössifies with the mesial margin of the prepalatine, satisfying me of the fact that it is nothing more than a semi-detached part of the palatine, it being ossified with it at both extremities.

Plenty of skeletons of the several species of the genus *Sphyrapicus* are to be found in my private cabinets, and when we come to study the skull and associated parts of one of these peculiar Woodpeckers we are met by a number of characters not seen in the picine skulls already considered above. Viewed upon superior aspect, the cranium of *S. thyroideus* is broad, rounded and smooth, calling to mind these parts as they appear in any small, ordinary passerine bird. The denting caused by the capital feather quills is only seen faintly in the fore part of the frontal region, which in these birds is very broad between the orbits. This breadth is extended to the base of the premaxillary, and this broad base runs quite abruptly to the apex of the upper mandible. This part of the skull is also much compressed vertically, causing the external narial apertures to appear quite slit-like. To some degree the frontals bulge over the premaxillary about as much in comparison as they do in the Imperial Woodpecker. Seen laterally, this skull presents us with a large pars plana, but apparently no os uncinatum. Internally the pars plana curves well backward, while on the other hand the anterior wall of the brain-case curves correspondingly forward. This all very much reduces the size and extent of the interorbital septum proper, which is here unpierced by any fenestra. The morphology of the turbinals is practically the same as in other *Pici* already considered, and a large free turbinal exists in the species of this genus. Either jugal-bar is short, straight and slender, articulating in the usual picine fashion with its quadrate behind. And this last-named element is strictly upon the Woodpecker model, while in the case of the pterygoid, its "snag" for muscular attachment is very long, and the palatine heads of these bones do not meet when articulated *in situ*. Further, the mesopterygoid does not reach as far forward as the palatine spur of the palatine of the corresponding side.

With respect to the palatines, they are interesting from the fact that the palatine spurs curve toward each other and the median line; but more than this, for when either of them passes the interpalatine spine of its own side it presents a shoulder for the apex of the latter to fit upon, while after this the palatine spur is continued forward as a delicate osseus spine for a short distance. There appears to be no vomer present in *Sphyrapicus*, and the maxillo-palatine are more than ordinarily reduced in size, while the great comparative breadth of this part of the skull takes them away still further from the prepalatine on either side.

As is well known, the hyoidean arches in this genus of Woodpeckers, although morphologically like others of the suborder, they nevertheless exhibit the notable feature in not having the thyro-hyals curve back over the cranium any more than they are seen to do in ordinary passerine birds.

The mandible is as in other *Pici*, with its symphysis rather deep and the posterior angular processes slightly more conspicuous. The ramal vacuity is entirely absent.

Quite a gap must exist between *Colaptes mexicanus* and such a form as *Picoides arcticus*—that is, if we be guided by what their skulls seem to indicate. In *Picoides* we meet with a skull that is possessed of a relatively very large cranial casket, globular and every way elegant in the extreme. It is uniformly and handsomely dented all over by the quill-butts of the capital feathers and is distinctly grooved for the thyro-hyals of the hyoid as far forward as the cranio-facial hinge. The frontals and nasals conspicuously roll over the premaxalline base, but the line here is not directly transverse, as it makes an obtuse angle, with its aperture looking forward.

The superior osseus mandible is very wide at the base, straight, vertically much compressed, causing the slit-like external narial apertures. These latter have their superior margins slightly tilted upward, as though the flattening of this mandible was becoming too great, and the nostril had made an effort later to enlarge its aperture.[1]

[1] Some meaning, too, must be attached to the peculiar way the frontal region bulges over the base of the premaxillary; possibly the continual hammering these birds indulge in to obtain their food may have in time produced this condition. At any rate it has the appearance as though the premaxillary had been pushed into the fore part of the skull. I have noticed, too, that it is in the skulls of the most inveterate hammerers that this feature is best developed. It is scarcely noticed at all in *Colaptes*, indeed it is quite absent there.

Parker often speaks of having found a lacrymal in the Woodpeckers, and here in *Picoides* one certainly seems to exist, and it is represented by quite a sizable flake of bone semi-attached to the posterior margin of either nasal. It may explain the little bit of a nib of a process found at the same point upon the nasals of some other *Pici—Ceophlœus*, for example. *Picoides* has an orbit that is veritably cup-shaped, which reduces the interorbital septum to almost *nil*, and proportionately the partition here between the orbits is quite as thick as it exists in certain caprimulgine types. Notwithstanding this a sizable fenestra pierces the septum in question. Os uncinatum, if present, is extremely rudimentary in character, while a foramen pierces the pars plana just within its external margin about midway up the plate. Other *Pici* show the same character.

Directing our attention next to the base of this skull, we are at first struck with the remarkably small size of the pterygoids, and this is enhanced by the relatively great proportions of the dome-like cranium that overshadows them. Each one develops a conspicuous "muscle-process," and the mesopterygoid is interesting from the fact that it is more paddle-shaped than in any other Woodpecker I have thus far examined. They do not reach forward to the hinder ends of the palatine spurs of the palatines, but hold a position more as we find it among the *Passeres*. The basipterygoid processes are entirely absent. A nasal septum ossifies anteriorly and is represented by a mesial thread of bone and small, semi-detached plates. I fail to find a vomer present in this species, but it may be very rudimentary; at any rate there is not much room for it at its usual site under the rostrum, for here the palatine on either side curls closely up upon the nether surface of that bar, and in a way I have not observed in other Woodpeckers. Perhaps the small vomer was lost during maceration; and at the present time I have but one skeleton of *Picoides arcticus*.

The posterior moiety of either palatine bone is but slightly wider than its prepalatine portion. For its whole length it is flattened, and the postero-external angle is inclined toward producing a process, which is directed bluntly backward and outward. A palatine spur is represented by a scraggly thread of bone, which on the right side passes forward above the interpalatine spine, to become attached again to the mesial margin of the palatine farther along. On the left side this connection is not made, so we have the usual

palatine spur, and further along on the edge of the palatine, anterior to the interpalatine spine, we fine a thread-like retral process, which condition is similar to what Parker saw in *Gecinus viridis* and other picine types on *both* sides.

Maxillo-palatine lobes are very small, and upon either side they are even markedly well separated from the corresponding palatine.

In *Picoides* the ends of the thyro-hyals of the hyoidean apparatus seem to extend no farther forward than a point opposite the cranio-facial hinge; while, with respect to its mandible, it only need be said that in it the symphysis is deep, and the posterior angular processes especially well produced for a Woodpecker. There is no ramal fenestra present.

Macgillivray, in speaking of the arrangement of the hyoidean extension over the skull in United States *Pici*, in Audubon's *Birds of America* (Vol. iv, pp. 288–289), says:

"In *Picus varius* the tips of the horns of the hyoid bone reach only to the upper edge of the cerebellum, or the middle of the occipital region.

"In *Picus pubescens* they do not proceed farther forward than opposite to the centre of the eye.

"In *Picus principalis* they reach to a little before the anterior edge of the orbit, or the distance of half an inch from the right nostril.

"In *Picus pileatus* they extend to half way between the anterior edge of the orbit and the nostril.

"In *Picus erythrocephalus* they reach to three-twelfths of an inch from the base of the bill.

"In *Picus tridactylus* they reach the base of the ridge of the upper mandible.

"In *Picus auratus* they attain the base of the right nasal membrane.

"In *Picus canadensis* they curve round the right orbit to opposite the middle of the eye beneath.

"Lastly, in *Picus villosus* they receive the maximum of their development and curve round the right orbit, so as to reach the level of the posterior angle of the eye."

This agrees very well indeed with the present writer's observations, but Macgillivray did not seem to take into consideration the fact that the ends of the hyoid exhibit *two* inclinations—one as in

Colaptes, where they essay to enter the right nostril, and the other as in *Dryobates*, where they essay to curve round the right orbit.

Now, in *Xenopicus albolarvatus* they reach far forward and exhibit an evident tendency to curve round the right orbit and succeed in coming down pretty well in front of it.

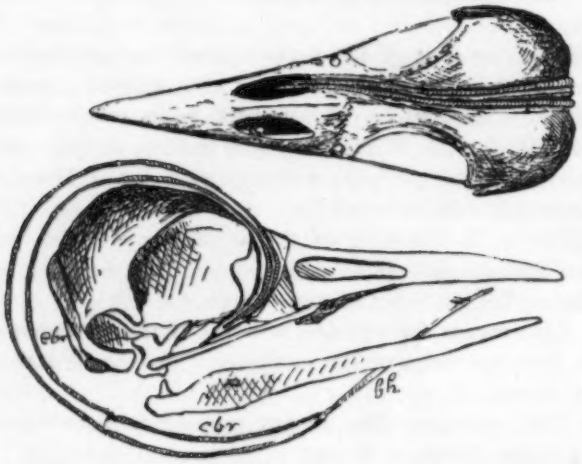


FIG. 6. (Upper one.) Superior view of the skull of *Colaptes auratus*, life size, showing the manner in which the thyro-hyals of the hyoid pass to the right nostril.

FIG. 7. (Lower one.) Right lateral view of a skull of a *Picus*, designed to show the second method by means of which the extremities of the hyoid are stowed away around the right orbit. *bh.*, basihyal; *cbr.*, cerato-branchial; *ebr.*, epibranchial. (Taken from Coues's *Key*, and both figures drawn by the present writer.)

Consequently, in *Xenopicus* we find the usual groove on the top of the cranium for the ends of the thyro-hyals and the rounded vault of the parietal and frontal regions. These are well dented by the quill ends of the capital feathers. This species of Woodpecker has a skull most nearly approaching that part of the skeleton in some forms of *Dryobates*, and reminds one but very little of any of the skulls in either *Spyrapicus* or *Melanerpes*.

In form the superior osseous mandible in *Xenopicus* is typically picine, being quite unlike what we find in such types as *Colaptes* and *Melanerpes torquatus*. At the base of the skull it is interesting to note that in this comparatively rare species there appears to

be a complete abortion of the basipterygoid processes, and there is certainly no vomer. On the pterygoids the muscle-process is but fairly well developed. On the palatines the interpalatine process is inconspicuously pronounced, while either "palatine spur" is delicate and passes forward to fuse with the mesial margin of the palatine from which it arises. A moderately large os uncinatum is seen and a small subcentral fenestra pierces the interorbital septum. Contrary to what we have found usually to obtain, a ramal vacuity of some size pierces the ramus of either side of the mandible.

When we come to compare the trunk and appendicular skeleton of *Xenopicus* with the corresponding parts of the skeleton of, say, such a species as *Dryobates villosus*, we will find still other points of resemblance between them. Just here, however, we pass to the consideration of the skull in the last-named species, which is the form I have selected to represent the genus to which it belongs. At the present writing I have beautiful skeletons of *D. villosus* before me, which I prepared from specimens collected for me by Dr. W. S. Strode, of Bernadotte, Ill.

Elegant in form and structure and eminently picine in character, the skull in *Dryobates* is truly a most interesting object to study. Externally the vault of the cranium is beautifully rounded and handsomely pitted by the quill ends of the capital feathers; further, a double gutter for the ends of the hyoidean apparatus is unusually distinct. The superior orbital rims are slightly tilted upward, and just within the margin of either one of them occur perforating foramina. Between these borders the frontal region is rather broad, while in front, between the nasals, it rolls or bulges well over the consolidated extremities of the premaxillaries. The superior osseous mandible is especially picine in character, being rather wide posteriorly, compressed vertically and directly drawn to an acute apex anteriorly. As already remarked, on its superior aspect it is *pushed into* the frontal boss behind. The culmen is represented by a raised ridge extending down the middle line to the apical extremity. Either external narial aperture is rather ample; the line of the lower margin of the opening being curved, while superiorly it is straight. Within the narial chamber the arrangement of the turbinals is as we have described them above from Parker. I would add, however, that the *free* turbinal upon either side is large and composed entirely of bone.

Upon lateral aspect we are to note that the "infraorbital bar" is very slender and straight; it is without a quadrato-jugal. Pars plana is ample and much curved and there is a fairly well-developed os uncinatum. The interorbital septum is a thickish plate, which shows a good-sized vacuity near its centre. Still more posteriorly it will be seen that the sphenotic and squamosal processes are both conspicuously developed, while anteriorly the nasal is very slender. By their approaching each other the long sphenotic process and the os uncinatum come within one-fifth of completing the orbital periphery, and the orbital cavity itself is deep, capacious and cup-shaped. Either tympanic bulla, although not strikingly large, has the usual cowrie-shell shape so characteristic of the skulls in the birds we have now under consideration.

I find no evidence of any basipterygoidal processes, and the basitemporal region is broad and smooth. Mesially the pterygoids nearly meet each other, and either one of these bones supports a conspicuous muscle-process. As for the mesopterygoidal portion of a pterygoid, it is rather broad and by no means reaches as far forward as the palatine spur of the palatine bone of its own side. A quadrate is as we find it in the *Pici* generally, but it is to be noted that the extremity of its orbital process is slightly expanded. Coming to a palatine, we are to observe that the post-palatine plate is slightly concaved upon its nether side, its postero-external angle is rounded off, and this entire division of a palatine bone is quite evidently separated from the prepalatine or more horizontal portion by a subconstriction just anterior to the spiculiform interpalatine spine. The palatine spur is strongly developed, and, as in *Xenopicus*, completely fuses anteriorly with the mesial edge of the palatine to which it belongs. This fusion of the anterior end of the palatine spur is at some distance in front of the interpalatine process, while opposite this last-named projection it often sends out a little osseous shoot that makes the feint to join with its apex—that is, with the apex of the interpalatine spine. A well-marked vomer is present, having the usual form and occupying the usual place, as is seen in the *Pici* generally, and which I have fully defined above. A thin or often thread-like septum narium also ossifies in this species of Woodpecker, and this extends backward for a variable distance in different individuals—in the example before me as far as the middle point midway between the very much aborted maxillopalatines. These latter are really more reduced than in any Woodpecker with which I am acquainted.

Passing to the mandible of *Dryobates*, it is seen to have the common V-shaped pattern of the Pici generally, with its symphysis rather deep, with its posterior angular processes well-marked, and with quite a sizable ramal vacuity in either of its rather vertically deep rami.

As has already been stated above (in the table quoted from Macgillivray's synopsis in Audubon), the hyoidean apparatus in *Dryobates* (*Picus*), in so far as its skeletal parts are concerned, is typically picine, and when the ends of the thyro-hyals arrive as far as a point opposite the light nasal bone they curve, and thence on pass nearly round the outer rim of the right orbit. The ear-bones I have not especially examined in this species, but they probably very closely agree with what Mr. Parker found in other Woodpeckers, and on this point I have quoted him above. With respect to the sclerotals of the eye, I find them in *Dryobates* quite like what we have given above for the Pileated Woodpecker and other forms.

This is all I have to say in the present place about the skull and the osseous structures more or less nearly associated with it in the *Pici*, so that next we will pass to the consideration of the remainder of the skeleton in this group of birds. Our remarks upon the skull were led in by an examination of that structure in the genus *Colaptes*, so back to *Colaptes* we go for material upon which to base our remarks upon the trunk and appendicular skeleton.

On the Skeleton of the Trunk and Limbs in the Woodpeckers.

Upon examining the vertebræ of the vertebral column of a specimen of *Colaptes mexicanus* at about the time the bird quits the nest, we find that there are nineteen of these bones between the skull and pelvis, which is the same as we will hereafter find in all true passerine types.

These vertebræ in the young *Colaptes* ossify from the same number of centres, and after the same fashion as they ossify in all of the higher groups of birds. *Ten* more vertebræ seem to enter into the formation of the pelvic sacrum; and, excluding the pygostyle, *six* more free ones compose the skeleton of the tail. Later on we will allude more particularly to these segments of the entire spinal column, and the peculiarly formed one that terminates the chain behind. The pelvis at this age still faintly shows the sutural traces

that indicate the boundary lines among the three bones that enter into its composition upon either side of the sacrum. Even at this age it is already strongly indicated that its sides are to be deep, its basin capacious, and its preacetabular portion comparatively narrow (see Figs. 9 and 10).

A rudimentary riblet may be suspended upon either side of the twelfth cervical vertebra, and a better developed pair occur on the thirteenth, while on the fourteenth cervical the pair of ribs, although freely suspended, possess well-marked epipleural or unciform appendages.

These latter are very large on the fifteenth, sixteenth and seventeenth pairs of ribs, small on the eighteenth, and entirely absent on the nineteenth, as they also are on the pair of sacral pleurapophyses. The four pairs of true dorsal ribs articulate with the sternum through the intervention of sternal or costal ribs, and the anterior pair of these latter are very conspicuous from their unusual bigness—not so much so in this nestling, however, as they are in the full-grown *Colaptes*, and still more so in adult individuals of other species of our *Pici*. Regarding the hæmapophyses of the sternal ribs, or rather pair of ribs, we observe that they do not reach so far as the costal border of the sternum upon either side. At this age the sternum is but subdeveloped, showing but imperfectly the pair of notches on either side behind, while the carina is shallow and the manubrial process not complete.

With respect to the shoulder-girdle in this young Red-shafted Woodpecker, I find that the hypocleidium is absent from the os furcula, and that this bone has its upper ends pointed. In front of either of these points we observe a flat, triangular piece of bone of some considerable size that lies against the head of the coracoid and the anterior extremity of the scapula of the same side. This piece ultimately fuses with the end of the clavicle, and thus either end gets to wear the form of the bone as we find it in the adult *Colaptes*. Probably this method of formation is common to all of our species of Woodpeckers.

The distal ends of the scapulæ are slightly expanded and rounded, and as yet but faintly suggest the peculiar form they take on in fully matured individuals.

Nestlings very imperfectly show the pneumaticity that eventually comes to so generally obtain in the pectoral extremity of the old birds of this species and some other *Pici*—for representatives of

this group have this feature quite strongly marked in their skeletons. Further consideration of this limb shows the presence of a good-sized os humero-scapulare; it shows the papillæ along the shaft of the ulna for the ends of the quills of the secondary wing-feathers; it shows the presence of a rudimentary sesamoid at the elbow; and it shows, even at this early age, the ossicles at the wrist number but two free ones, all the others having duly fused with the proximal extremity of the metacarpus. Peculiarities of the bones composing the hand can best be studied in old birds, which we will do further on.

Upon examining the skeleton of the pelvic extremity in this nestling, I find ossification of the several bones composing it so far advanced that nothing would be gained by a description of them in their present state, and it will be better to study them also in a matured individual. Students will comprehend just how rapid this ossification has been when I tell them that even at this early stage of this Woodpecker's development the line of sutures between the condyles and the lower end of the shaft of tibio-tarsus has been absorbed, a condition which likewise obtains in the femur. A goodly patella has also ossified.

Taking up next the skeleton of an old individual of *Colaptes mexicanus*, we find some very good characters in its vertebral column, in addition to those described above. With respect to the atlas, it is peculiar in having the vertebrarterial canal, upon either side, *completely enclosed by bone*. It also has a very broad neural arch, and its cup for the condyle is unperforated in many specimens. In the axis we find both neural spine and hypopophysial process prominently developed, and in this vertebra the vertebrarterial canal is also present and of some length, being enclosed by bone. Both atlas and axis are highly pneumatic, as are all the free vertebræ of cervical and dorsal regions. This not only obtains in *Colaptes*, but in other *Pici*. Conspicuous neural spines are also seen upon the third and fourth vertebræ, with less evident hypopophysial ones. In both these last a broad interzygapophysial bar exists upon either side, and with regard to the remaining cervical vertebræ they are chiefly noted in not possessing parial parapophysial spines, those processes so characteristic of the mid-cervical vertebræ in the vast majority of the *Passeres*. Zygapophysial processes in these vertebræ are short and thick, which fact lends a peculiar

solid appearance to the mid-cervical segments from a posterior view. A hypopophysial canal is well marked, and this in the tenth, eleventh and twelfth vertebræ is replaced by very large and strong processes.

Among these segments the usual form of articulation that we find in the highest groups of birds prevails both anteriorly and posteriorly.

In the dorsal division of the spine large neural spines are present and the diapophyses are long and broad, developing at their outer extremities, above, short spine-like metapophyses.

Pneumaticity obtains in the case of the thoracic ribs, and these bones are rather wide in the antero-posterior direction and compressed transversely. The epipleural appendages are broad and not lengthy, usually in any case only reaching to the middle of the next succeeding rib. They always fuse with the margin of the latter.

Foramina for the admission of air are likewise to be seen at the ends of the true costal ribs.

Very spreading and somewhat downwardly-inclined transverse processes characterize the six free caudal vertebræ in *Colaptes*. Their centra are small and the bones are not pneumatic. The neural canal is almost capillary in its calibre, while in the two ultimate segments a coössified, strong chevron bone is seen, which is likewise pierced antero-posteriorly in the last one by a foramen. This foramen is also carried on through the lower part of the peculiarly formed pygostyle. The neural spine of the last-mentioned is lofty, being thin-edged in front and on top, while posteriorly it is thicker. This bone also coössifies with the caudal vertebra next in front of it, the transverse processes of which remain undiminished in size. Behind, the pygostyle at its lower part flares out as a broad, transversely-disposed hexagonal plate of bone, constituting a well-known character of the *Pici*.

So far as number of vertebræ is concerned and arrangement and number of ribs, *Dryobates* essentially agrees with *Colaptes*, but in the former we find some interesting morphological differences. In *Dryobates* the cup of the atlas is always perforated, and at the sides of this bone, either upon one side or the other, the osseous span for the vertebrarterial canal may not be quite complete, while on the other hand the hypapophysial canal for the carotid artery is entirely surrounded by bone, and the union below is firm. The last five cervicals support long hypopophyses which are narrower

in mid-series than they are at the ends; the leading dorsal vertebra also bears one of these processes, while the neural spines to the last-mentioned are lofty and comparatively narrow antero-posteriorly, and a somewhat reduced one is found on the last cervical. Epipleural appendages are seen upon all the true dorsal ribs, but they are absent from the extremely slender pair of sacral ribs. The last pair of cervical ribs are peculiar in being very stout and broad, and from this pair backward through the dorsal series they diminish in width. Most curious of all is the great size of the anterior pair of sternal ribs, and it is not clear to me at the present writing why they should be so. There is no canal passing through the ultimate chevron bones and the lower part of the pygostyle in the skeleton of the tail in *Dryobates*. Excepting a few minor departures, the part of the skeleton we have now under consideration in the Ivory-billed Woodpecker essentially corresponds with what we see in the last-mentioned genus. *Campephilus*, however, does not have its carotid canal completely closed in—the canal is found through the chevron bones of the caudal vertebræ—and a very high state of pneumaticity exists throughout. *Xenopicus* likewise agrees, as does the Pileated Woodpecker (*C. pileatus*), and in it the chevron bones are pierced by a canal which is extended through the enormous pygostyle of this bird. It, too, has the vertebrarterial canals of the atlas and axis entire.

Picoides arcticus presents us with nothing in its vertebral column and ribs in any way at variance with what we have in general found among other Woodpeckers above. In it, as usual, the atlas is pierced on either side for the vertebrarterial canal, and the carotid canal is slighly open in mid-cervical series, but completely closed and very small in the last vertebra or two. Nineteen free vertebræ are found between skull and pelvis, and six with a large picine pygostyle in the skeleton of the tail.

In a specimen of *Melanerpes erythrocephalus* at my hand I also find nineteen free vertebræ from occiput to pelvis, with six free tail vertebræ and a pygostyle. Generally speaking, the characters of these and the ribs connected with them are much the same as we have already described above for representatives of other American picine genera, but still there exists a specific shading difference hard to define. The vertebrarterial canal or foramen is closed in by bone on one side, open on the other in the case of the atlas, and the cup of this bone is largely perforated by an odontoidal fenestra. The

ribs appear to be slenderer and the hyapophysial processes of the last cervical vertebra not so strongly produced. A foramen, median in position, perforates the lower part of the pygostyle, as I have called attention to in some other Woodpeckers.

The first pair of sternal ribs are comparatively not so stout as they are seen to be in *Dryobates*.

Coming next to consider such a form as *Melanerpes torquatus*, we find the same plan prevailing; in it, however, the pre- and post-zygapophyses of the mid-cervical region are rather more spreading; the upper parts or moieties of the dorsal ribs are again broad; the leading pair of hæmapophyses are barely larger than the remaining pairs. This is quite a striking difference as compared with what we saw, for instance, in *Campephilus*. With respect to the caudal vertebræ, we find their transverse processes narrow and long, while the chevron bones, coössified with their centra beneath, are simply bifid, and the spreading part of the pygostyle, comparatively speaking, is not as large as usual. Finally, the neural spines of the dorsal series of vertebræ are very low, and the ends of their superior borders interlock both in front and behind.

Some very noted differences are to be seen in this part of the trunk skeleton when we come to compare *M. torquatus* and *M. carolinus*. First, in the last-mentioned species the post- and pre-zygapophyses of the mid-cervical vertebræ are not nearly so slender nor divergent; it has but five free caudal vertebræ,[1] and a large submarginal foramen pierces the pygostyle below.

There are also other minor differences which are to be recognized upon careful comparison. Right here I wish to point out a difference that exists in the axis vertebra of the Pileated Woodpecker and the same bone in *Dryobates*, *M. torquatus* and *M. carolinus*. In the first this segment of the spine is pierced upon either side by the vertebrarterial canal, while in the last-mentioned species the vertebral artery and vein skip this vertebra and pass directly from the canal in the third cervical to the corresponding canal in the atlas.

Melanerpes uropygialis exhibits some characters in its vertebræ and ribs that agree with the corresponding ones in *M. torquatus*, while others agree with *M. carolinus*. For instance, it has *six* free caudal vertebræ and the pygostyle, the latter showing the

[1] Determined from two specimens sent me by Dr. Strode.

medio-submarginal foramen. One peculiar character is seen in this handsome Woodpecker, and it is in the first or anterior pair of its dorsal ribs. Here the epipleural appendages, the one on either side, fuse with the margin of the rib for the entire length of its superior border. In other words, the epipleural appendage is parallel with its rib, its upper margin being coössified with the posterior or adjacent border of the rib to which it belongs.

None of the species of the genus *Sphyrapicus* seem to present us with any very marked departures from what I have attempted to give above in reference to their spinal column and ribs. They have *six* free caudal vertebræ, the fenestra exists in the pygostyle, the atlas is perforated for the passage of the vertebral vessels on either side, and the ribs seem to be slenderer than is usual among Woodpeckers.

In this genus, in *M. carolinus* and no doubt in some others, the lower ends of the last pair, or "floating costal ribs," coössify with the hinder margin of the costal rib in front of them. This is not the case in *Dryobates*, *Picoides*, nor in some others; it may occasionally be seen in the Pileated Woodpecker.

Let us next consider the sternum in some of the *Pici*. Several characters of this bone are held in common by all the representatives of the group. It is always found to be highly pneumatic, with the foramina between the facets on the costal borders; secondly, on the thoracic aspect (1) down the median line, (2) transversely within the anterior border, and (3) a large median one at the base of the manubrium. The carina is comparatively shallow, and notably extended forward beyond the body of the bone. Either costal process is lofty, pointed, with all the facets for the costal ribs arrayed down its posterior border. In front, a more or less bifurcated manubrium is seen. Behind, the body of the bone is expanded, and profoundly two-notched upon either side, thus giving the xiphoidal processes dilated posterior ends.[1]

The costal grooves are prominent, separated mesially, and a small subcircular facet is found at the termination of either one of them externally. They are for articulation with the coracoids.

[1] In the sternum of a specimen of *Colaptes mexicanus* at my hand the inner notch of the left pair is a large subelliptical foramen, caused by the fusion of the inner tip of the process with the outer tip of the adjacent angle of the body of the bone.

In *Colaptes* the manubrium is strongly bifid, pneumatic foramina occur at all the points mentioned above, the notches of the hinder part of the body are profound, and the anterior border of the carina is convexed forward. In *Campephilus* the manubrium is small and feebly bifid, and there is no median pneumatic foramen posterior to its base; the articular borders of the costal processes are very broad transversely; the body of the bone is much expanded posteriorly, though the "notching" is comparatively shallow; the anterior carinal border is irregularly scalloped.

In the Pileated Woodpecker we find a sternum closely resembling the bone in *Campephilus*; in it, however, the notches are comparatively deeper, the bifurcation of the manubrium more evident, and the carina comparatively deeper. This notching of the xiphoidal margin of the sternum though is found to vary with respect to its profundity in different individuals of the two last-mentioned genera.

Dryobates has a typically picine sternum, with a bifid manubrium, and the anterior border of the carina nearly straight and vertical—a condition that is likewise present in the bone in *Xenopicus*.

Picoides arcticus exhibits nearly the same characters with the last two, but in it we find a sternum that calls to mind the bone as it occurs in some of the *Passeres*. The carina is deeper and not so prominently brought forward in front. Four notches behind, however, dispel the resemblance.

Changing pattern again in *Melanerpes torquatus*, we find a sternum with a shallow keel, with a conspicuously produced fore part; a subaborted bifid manubrium; a shortish body, with thin costal processes; and, finally, the bone less pneumatic than is the rule among Woodpeckers. Some of these features are carried still farther in *M. carolinus*, where pneumaticity of the bone is at its minimum, and the bifurcations of the minute manubrium are almost or quite aborted. In this species, however, the xiphoidal processes are slender, and the notches that create them more than usually deep. All this agrees very well with what we find in *M. uropygialis*, but in the sternum of this bird the carina again is very shallow and the "notches" not strikingly deep—at least not nearly as much so as they are in *M. carolinus*.

Other species of this genus show some slight individual peculiarities in their sterna that, taken in connection with other characters, ought to some day assist in determining affinities.

In *Sphyrapicus* the xiphoidal processes are uncommonly slender; the body of the bone thin and delicate;[1] while the horns of the manubrium are a little larger again.

All of our species of Woodpeckers possess an os humero-scapulare at either shoulder-joint. It has much the same form and relative size as we find it in birds of comparative proportions among the Passeres. With respect to the several bones of the shoulder-girdle, however, they are seen to have quite dissimiliar patterns among the *Pici*, although the general plan or form is the same. Most curious do we find a scapula to be in *Colaptes*. It is fashioned like a flattened great J, with the curved portion enlarged and directed outward. Either coracoid has a long, slender shaft, with the head of the bone much produced upward, and compressed from side to side. At its sternal extremity we find a sharp, thin, hook-like process at its outer aspect, with two concave, transverse facets below, and a small subcircular one at its suprainterno-mesial angle. As we know, these facets are for articulation with the sternum. The glenoid facet at the other end of the bone is long and narrow, and is inclined to be convex outward rather than a "cavity," as it really is on the scapula. Os furcula is of the typical U-shaped pattern, with enlarged, triangular, transversely compressed heads, and no hypocleidium below. The clavicular limbs are delicately constructed, and likewise compressed in the transverse direction. All the bones, with perhaps the exception of the furculum, of this arch are highly pneumatic, and when articulated *in situ* the great, flattened, subtriangular head of the furculum on either side is lain flat against the scapula and coracoid, which in turn are articulated in the usual manner.

Adult Ivory-billed Woodpeckers possess a strong pectoral arch, and in this species all of the bones composing it are thoroughly pneumatic. Relatively they are considerably shorter than the corresponding bones in a *Colaptes*, with their extremities somewhat stouter. The scapula does not especially remind us of a J, although its posterior end is abruptly turned outward, but it is about at right angles with the shaft and not enlarged or curved any. Proportionately speaking, the coracoidal end of a scapula in this

[1] I have one specimen that shows a normal circular fenestra in it on the right side, just anterior to the inner notch, and probably this character will be found in a certain percentage of the sterna of this species, *S. v. nuchalis*, as well as others of the genus.

species is tuberous and the pneumatic foramina upon its anterior face large. A coracoid lends but a limited share of the articular surface for the head of the humerus, but a large, subtriangular facet is seen upon the scapula for that purpose.

In *Melanerpes torquatus* the same general characters as we have described obtain, but, as we would naturally expect, the several elements of the arch possess a peculiar facies of their own. A blade of a scapula, for instance, is vertically compressed, while its enlarged posterior end is not nearly so abruptly turned outward as it is in *Colaptes*. At the lower outer angle of the sternal end of a coracoid, the process is handsomely developed and the facets below very distinctly defined. This last description agrees pretty well, too, with what we find in *M. carolinus*, though good differences exist in minor details. *Dryobates villosus* has the posterior end of either scapula bent out at a right angle with the shaft, which is also the case in *Xenopicus*, while in *Ceophlæus* all the bones of the arch are fashioned more as we find them in *Campephilus*.

Various species of *Sphyrapicus* show all the picine characters of the bones of the shoulder-girdle, and in them the hinder ends of the scapulæ are enlarged and stand at a right angle, in either case, with the shaft.

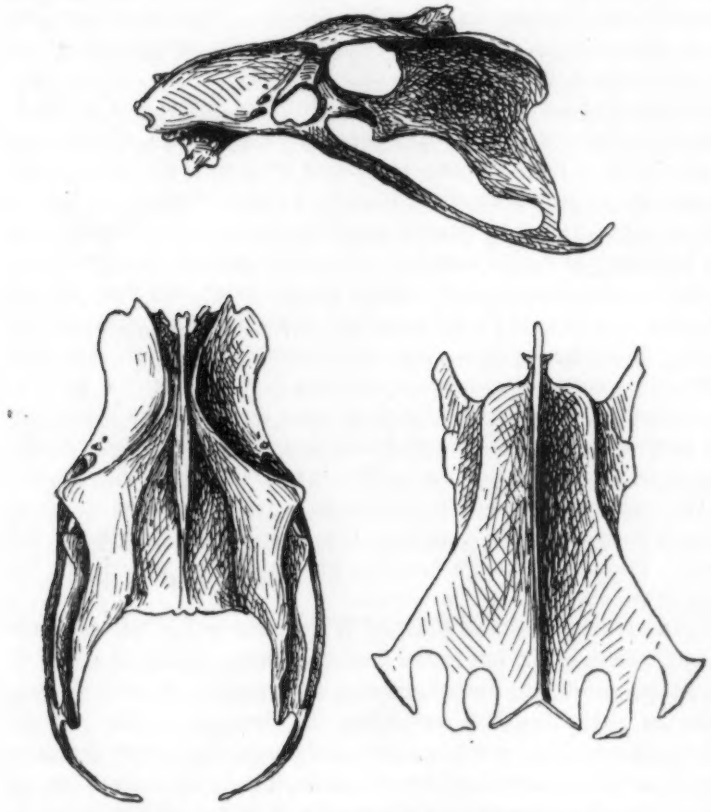
Very conspicuous indeed is the process at the outer aspect of the sternal end of a coracoid, it being sharp-pointed and somewhat turned backward.

In some Woodpeckers, as the Ivory-bill, this last character would hardly attract especial attention. It is but moderately marked in *Picoides*, a bird which also has a typical picine pectoral arch.

Any American Woodpecker is always possessed of a large, capacious pelvis, and in *Colaptes*, when we come to view the bone from above, it is seen to have a moderately extensive pre-acetabular region, with a much larger post-acetabular one. An ilium is pointed in front, and these bones diverge from each other as they proceed forward. This creates a canal of increasing size on either side of the prominent crista. Posteriorly the "sacrum" fuses completely with the ilia and presents behind more or fewer small parial, interdiapophysial foramina.

At the side, the antitrochanter is small, though prominent; the ischiadic foramen of good size; a large obturator space merging with the small subcircular obturator foramen; a circular acetabulum with its base entirely absorbed. There is no propubis, and

the postpubic bone is long and slender, being produced well beyond the ilia on either side behind. Sometimes it fuses with the foot-like process sent down by the ischium. Superiorly the hinder margin of the ischium is roundly concaved, the lower part being convexed outward. Upon the aspect now under consideration we see that the pelvis is rather deep. This feature is very characteristic of such a form as the Ivory-billed Woodpecker (see Fig. 8).



STERNUM AND PELVIS OF IVORY-BILLED WOODPECKER.
(*Campephilus principalis.*)

FIG. 8. (Upper one.) Left lateral view of the pelvis.
FIG. 9. (Left-hand one.) Superior view of the same bone.
FIG. 10. (Right-hand one). Anterior aspect of sternum.
All figures life size from nature by the author from specimen No. 18578 of the collections in the United States National Museum.

The calibre of the neural canal is subcircular and not large, and swells but little for the enlargement of the myelon where the sacral plexus is given off. One thing strikes us as peculiar in this pelvis, and that is upon its ventral aspect there is no lengthening nor any other change in the transverse processes of the vertebræ opposite the acetabulæ. It is well known that in a great many birds these are increased in size and strength and thrown out as buttresses against the ilia as a means of support for these points, they being opposite the articulation of either femur. Anteriorly there are three vertebræ that throw out their diapophyses against the ilium on either hand.

In *Dryobates* the general character of the pelvis is the same, presenting but few specific differences. Viewed from above there is seen to be a flush, smooth and level area mesially situated between the points where the "ilio-sacral canals" terminate behind and a pair of triangular depressions over the sacrum posteriorly for the lodgment of caudal muscles. This is also fairly well marked in *Colaptes*. In *Xenopicus* the pelvis is very much like that bone in *Dryobates*, while in *Picoides arcticus* it has a pattern peculiarly its own. Here the pelvis is short antero-posteriorly, with very deep sides, and post-pubic elements scarcely produced at all behind. Moreover, in *Picoides* the obturator space is shut off by bone from the large subcircular obturator foramen, and the downward projecting process of either ischium behind is exceedingly small.

The pelvis of *Melanerpes torquatus* reminds me very much of the pelvis in *Colaptes*, it having the same general character and form. The same remark applies, though not so strictly, to the bone as we find it in *M. carolinus*.

In the Ivory-billed and Pileated Woodpeckers the pelves much resemble each other, but in the first-mentioned species the side of the bone posterior to the acetabulum is comparatively much deeper, while in the Pileated Woodpecker the descending foot of the ischium is relatively much broader and always fuses with the superior edge of the post-pubis where it meets it. In both these species the pelvis is largely pneumatic, a condition that obtains to a greater or less degree for this bone in all of our *Pici*; least so, perhaps, in such a type as *Sphyrapicus*. *Sphyrapicus v. nuchalis* has a pelvis quite picine in all its characters. Some good distinctive features present themselves when we come to compare such a pelvis with the pelvis of *Tyrannus tyrannus*.

In the Tyrant Flycatcher to which I allude (1) the parial foramina of the post-acetabular region are present and large. They are absent in the Woodpecker. (2) In *Tyrannus* the descending process of the ischium is slender and nearly straight; its foot does not coössify with the post-pubis. (3) The Tyrant Flycatcher has the obturate space and foramen separated by a delicate bridge of bone. They merge into one fenestra in the Woodpecker. (4) *Tyrannus*, on the ventral aspect of the basin of the pelvis, opposite the acetabulæ, has the transverse pleur- and diapophyses thrown out as abutments against the ilium, upon either side, as tie-beams. No modification of the parts mentioned is to be seen in *Sphyrapicus*. (5) *Tyrannus* has its ilio-neural canals open behind upon either side of the sacral crista. They are closed at those points in the Woodpecker.

Before passing to the consideration of the appendicular skeleton it will be as well to add here that I have glanced at the ossifications that occur in the *trachea* of *Colaptes*, and it will be seen that both the rings and the semirings are thoroughly ossified. At the upper extremity we find the usual bony thyroid plate, also arytenoid bones of a peculiar form. Each one develops two bifurcating limbs behind, which gently curve toward each other, and thus enclose or nearly enclose a subelliptical fenestra. Their free ends articulate with the corresponding side of the median bone at its upper tip. At the syringeal end of the trachea we find an ossified pessulus, with the ossified semirings below it. The form of the tracheal rings seems to correspond with the corresponding structures as we find them in most all ordinary birds.

Of the Appendicular Skeleton in the North American Pici.

So far as the pectoral limb is concerned, I may say I have examined it and compared it in some nineteen or twenty species of our Woodpeckers, and find that although there are some few distinctive characters, these appear for the most part to be slight, and in such a work as the present one need hardly be dwelt upon in detail. Pneumaticity, however, seems to differ among them in so far as its extent goes, for in *Colaptes* I find humerus, radius and ulna all pneumatic, while in *Melanerpes torquatus* only the first-mentioned bone enjoys that condition.

Ceophlœus pileatus offers us a very good average species wherein to study the characters presented on the part of this limb, and it

will be made to stand here for the group in this matter. An adult specimen of this form has a humerus measuring 5.4 cms. in length, an ulna of 6.5 cms., radius of 5.8 cms., and a total length of the skeleton of manus 5.1 cms.—a very well-proportioned limb.

Owing to its large pneumatic cavity, the humerus is very light, while, on the other hand, its shaft is large round. It exhibits the usual sigmoid curve, and the extremities of the bone are considerably expanded. The radial crest is long and rather prominent, and the ulnar tuberosity well over-arches the pneumatic fossa. At the base of the fossa the air-holes are very fine, and form a diffuse group of apertures leading into the humeral shaft. Between the ulnar tuberosity and the head of the bone a deep, oblique groove exists.

At the distal extremity the radial and oblique tubercles occupy their most usual positions, there being quite a prominent tuberosity on the radial border of the shaft immediately above the latter, and a still more conspicuous process produced distally below the former from the ulnar border of the bone.

The radius is nearly straight and slender; its shaft is quite uniform in calibre throughout. Its extremities exhibit the usual ornithic characters.

FIG. 11. Left ulna of *Colaptes mexicanus*, natural size, drawn by the author from a specimen in his own collection. *q* directs attention to the elevated osseous papillæ on the shaft for the insertion of the ends of the quills of the secondary feathers.

Nothing especial characterizes the ulna of the Pileated Woodpecker beyond the remarkable row of elevated papillæ down the

subpalmar aspect of its shaft. There are seven of these, and appear upon this bone in all of our *Pici*. Beyond this the ulna is seen to be a stout bone with subcylindrical shaft, the latter being nearly straight for its distal moiety—curved along its proximal half.

The olecranon process is well produced and all the articular facets and trochleæ of this bone are of good size.

A single sesamoid of no great size is found at the elbow, and in the adult Woodpecker the carpus is composed of the usual two free bonelets, the ulnare and the radiale. These latter possess each the form they are seen to have in most all ordinary birds, and their articulations also correspond.

The carpo-metacarpal bone of the hand has a few characters that should be noticed. Among these we observe that the articulatory facet or trochlea formed by the os magnum is, upon the anconal side, brought well down upon the shaft. Its border is rather thin-edged, and on the whole this part is compressed from side to side. Below the head of the bone there is seen a thin, laminated process coming off from the posterior aspect of the index metacarpal that laps flat over against the upper third of the shaft of the mid- or smaller metacarpal at its outer aspect. Such a process we will also find in this bone among the *Gallinæ*, *Passeres* and other groups.

The lower end of the midmetacarpal extends considerably below that end of the larger or index metacarpal, a state of affairs that is reversed in some birds, as in the *Trochili*.

Both pollex and distal index phalanges are comparatively small and pointed. They are without claws. The large proximal phalanx of the index digit is peculiar in that its posterior blade-like part is much reduced, and it is only distally that this part is produced a little, curves upward and meets the lower extremity of the small free phalanx of the middle or last finger. This last-mentioned phalanx is, contrary to the rule in ordinary birds, larger than either the pollex digit or the distal one of index, and is distinguished by having a tubercle projecting from the posterior aspect of the proximal third of its shaft.

Passing now to the consideration of the pelvic limb of the Pileated Woodpecker, the species in hand, we find that in the adult the femur measures 4 cms. in length, the tibio tarsus 5.4 cms., the tarso-metatarsus 3.7 cms., and the longest or outer

anterior toe 3.6 cms. The fibula rarely exceeds 3 cms. in length.

Besides the rather small patella, there are found one or more minute sesamoids in the tendons of the muscles that attach to the lower end of the femur, especially in that tendon which inserts itself between the femoral condyles (flexor longus hallucis). In it one appears to be constant.

Always pneumatic, the femur is characterized by a large air-hole situated at the usual site, when it occurs in this bone in *Aves*. A very shallow excavation for the ligamentum teres is found upon the femoral head, and the trochanter is not elevated above the articular surface at the summit of the shaft. This latter is nearly straight, subcylindrical on midsection, and is scarred by the usual muscular lines. As to the condyles, they are not large, and they offer us only the usual ornithic characters; the external one, being the lower, is grooved behind for the head of the fibula and has a small pit-like depression immediately above it. The popliteal fossa is shallow, as is also the rotular channel in front.

Tibio-tarsus possesses a large head, which is compressed antero-posteriorly, spread transversely, and is further characterized by having the cnemial crest well raised above the summit of the bone, while both pro- and ectocnemial processes are quite aborted or very nearly so. From end to end the shaft is slightly bowed outward or toward the fibula side. A line down its front is, however, practically straight. What appears to represent the "procnemial ridge" is here a thin crest passing down the upper half of the shaft upon its inner aspect. Directly upon the opposite side of the bone is seen the "fibular ridge," which is low proximally, and gradually increases in height to its termination below. This form of the ridge has the effect of keeping the distal end of the somewhat feeble fibula well away from the tibio-tarsal shaft. And it is about opposite the midpoint of this latter that we see the free pointed end of the fibula as it is held in that position.

Returning to the tibio-tarsus, we have still to observe that the usual osseous bridgelet crosses the tendinal canal at the antero-distal aspect, and that a tubercle is found above it upon either side, the outer one being the lower upon the shaft. The condyles are large, nearly of equal size, directly opposite each other

and separated in front, below and behind by a deep intercondylar notch. A pit is seen in the middle of this, below, for a conspicuous process standing up on the summit of the tarso-metatarsus.

Antero-posteriorly the articular facet on the summit of the fibula is concave. Just now I invited attention to the erect process standing between the concave articular facets upon the summit of the tarso-metatarsus in the Pileated and other Woodpeckers. This bone of the leg shows further that its hypotarsus is bulky, being both deeply grooved and perforated for the passage of the tendons. Its shaft is straight, rather small comparatively, and only slightly grooved down its length in front and not so at all behind. Distally the trochleæ are large and prominent, and among our *Pici* we find two patterns of these, one being as they occur in *Ceophlœus*, now in hand, and the other as they occur in the three-toed forms, such as *Picoides*. They differ, however, but very little, as the difference in *Picoides* is a suppression of the first toe and the small, free first metatarsal. Evidently this does not affect the form of the trochleæ of the tarso-metatarsus to any extent.

Turning to the Pileated Woodpecker again, we find a very interesting state of affairs, for the trochlea for the inside anterior toe is single and much compressed lateralwise; the one for the outer anterior toe is double, or, in other words, has two condyles with the median valley running round between them. Then comes the single trochlea again for the fourth toe or the outside hinder one. It is turned to the rear and articulates with the basal joint of the reversed toe. Posterior to this is a very large, irregular, freely-projecting trochlea, which articulates with a sesamoid at the back of the foot. This sesamoid is moulded on to the inner side of the base of the basal joint of the reversed toe and to some slight extent on to the base of the basal joint of the hind toe proper. Indeed it stands between them, and the trochlea intended for it is fully three times as large as the one for the fourth or reversed toe.

The accessory metatarsal is comparatively very small and freely suspended as usual. Considerable feebleness seems to characterize the true hind toe of the Woodpecker under consideration. Its basal joint is much compressed from side to side, and indeed this is the case with all these joints of the podal digits, it being especially noticeable in the first and second toes. The osseous claw to the first toe is also comparatively small, but the outer

three ungual joints are powerfully developed. So far as the number of joints is concerned they range as in the *Passeres*, normally—*i. e.*, two, three, four and five for first, second, third and fourth digits respectively—the anterior toes having three (inner) and four (outer) joints devoted to them, while the posterior ones have two (inner) and five (outer), thus showing the reversed toe to be the fourth of the typical avian pes.

Summary of the Chief Osteological Characters of the North American Pici.

1. Large but simple-scrolled turbinals; there may be a free turbinal.

2. Bulging of the frontal region over the transverse cranio-facial line may (*Picoides*) or may not (*Colaptes*) exist.

3. Generally the external cranial vault is more or less dented by the ends of the quills of the capital feathers.

4. The interorbital septum is sometimes entire and sometimes shows a fenestra.

5. Pars plana large, and often the os uncinatum is well developed.

6. Lacrymal usually vestigial in character.

7. Quadrato-jugal aborted.

8. Tympanic bullæ cowrie-shell-shaped and otherwise peculiar.

9. A large spur on the upper side of either pterygoid for muscular attachment.

10. A median, dagger-shaped vomer sometimes present, but sometimes absent.

11. Maxillo-palatines rounded lamina and very much aborted.

12. A more or less imperfect nasal septum usually present.

13. Vestigial basipterygoidal processes are distinctly developed in some species.

14. As ossification advances in the palatines it may be characterized as being "ragged" along the antero-mesial and antero-external margins of these bones. This often leaves little osseous islets not absorbed, a few of which may persist here and there throughout the life of the individual.

15. Either palatine is characterized by possessing an "inter-palatine spine," or process, and this may be continued forward to fuse with the mesial border of the bone by its free tip. Either palatine also possesses a palatine spur springing from the anterior point

of the internal lamina of the bone, and being directed forward. It may also in some species pass on to fuse with the mesial edge of the palatine to which it belongs by its free end. The postero-external angle of a palatine is either truncated or shows various degrees of being bluntly rounded.

16. The mesopterygoidal process of a pterygoid is not paddle-shaped, but long and narrowly pointed.

17. Distinct orbito-sphenoids exist in the nestling.

18. Mandible very strong, typically V-shaped in pattern; sides deep; symphysis varies in depth; ramal vacuity absent, or minute if present, and never large. Posterior angular processes more or less truncated; internal angular processes large. In some species the posterior third of the inferior ramal border somewhat tumefied and roughened.

19. Rudimentary cerato-hyals which early fuse together.

20. Uro-hyal absent.

21. Elongated thyro-hyal elements curl up over the cranium to a greater or less extent. They may pass round the right orbit. They may come to the posterior margin of the right external narial aperture. They may hardly come up on the cranium at all. Whenever they do the cranium is usually externally furrowed to receive them.

22. Sclerotal plates of the eye commonly fuse completely together around their external periphery and toward the centre.

23. "Double 'infrastapedial' and ossified stylohyal" (Parker).

24. Rings, semirings and other parts of the trochea ossify.

25. There are nineteen free vertebræ between the skull and pelvis; the vertebrarterial canals pierce the atlas and in some species the axis; the atlantal cup is perforate; there are no parial parapophyses; the carotid canal may or may not be entirely closed in by bone; where they are present the neural and hæmal spines are usually very large. There are three pairs of cervical ribs, five pairs of dorsal ribs and one pair of sacral ribs. The hæmapophyses of the latter do not reach the sternum. In some species the first pair of costal ribs are very robust, as are the last pair of cervical ones. There are five or usually six tail vertebræ (free), with an enormous pygostyle. Most of these parts are highly pneumatic.

26. The sternum is two-notched on either side of the carina; the manubrium is either slightly or very much bifurcated; the costal

processes are long and pointed, and the keel is usually rather shallow, projecting forward and carried up under the manubrial process. The sternum is usually quite completely pneumatic.

27. In the pelvis we find the ilia gradually diverging from the sacral crista as they pass forward. Parial interdiapophysial foramina are either very minute or entirely absent. Ischial notch on the posterior margin of the bone long, rounded and shallow. Acetabulæ large, and bases completely absorbed. Sides of pelvis usually very deep. Postpubic slender, extends beyond ischium, the foot of which latter may or may not fuse with it. Obturator space large, and may or may not merge with the obturator foramen. *Three* of the vertebræ of the sacrum anteriorly throw out their processes against the ventral iliac walls. The pleurapophysial and transverse processes of the sacral vertebræ opposite the acetabulæ are not modified and lengthened so as to act as braces at the points in question. The pelvis is commonly completely pneumatic.

28. Bones of the shoulder-girdle pneumatic, with sometimes the exception of the os furcula. This latter is of the U-shaped pattern, without hypocleidium; large, flat, scapulo-coracoidal ends (which originate from separate ossific centres in the young), and with laterally compressed limbs. Posterior end of scapula more or less modified to be bent or to curl outward, giving the bone a very unique form. Coracoids long, not very stout, and with the anterior end more or less laterally compressed.

29. An os humero-scapulare present at either shoulder-joint; functional, and has much the same shape as the ossicle has in the *Passeres*.

30. Either the humerus alone, or it together with the long bones of the antitrachium, may be pneumatic. A small sesamoid is found at the elbow. Seven prominent osseous papillæ occur, at nearly equal distances apart, down the shaft of the ulna. The flat, rounded process from the postero-upper third of the shaft of index metacarpal is present. The slender last metacarpal extends below the one of index, and its free digital joint is *larger* than either of the other terminal phalanges. The proximal phalanx of index digit has its posterior blade almost entirely aborted. There are no claws.

31. Femur is always pneumatic, and so may be the tibio-tarsus in some species. In the former, trochanter major does not rise above the summit of the shaft; the excavation on the head is very

shallow. Shaft nearly straight; condyles rather small; popliteal fossa and rotular channel very shallow. *Pici* possess patellæ. Cnemial crest of tibio-tarsus elevated above summit of bone, with pro- and ectocnemial ridges nearly or quite aborted. Condyles of this bone very distinct, and intercondyloid valley very deep. Bony bridgelet confines tendons in front. Fibula short and free; its lower spicula-like end being held well away from shaft of tibio-tarsus by the increasing height of fibular ridge on the latter bone.

Hypotarsus of tarso-metatarsus both grooved and perforated for passage of tendons. An erect process occurs on the summit of this bone of the leg. Its shaft is nearly straight, and its terminal trochleæ are specially modified to meet the podal requirements of the picine zygodactyle foot.

Joints of pes normal—two, three, four and five to first, second, third and fourth toes respectively. Fourth toe permanently reversed, and first toe, together with its free metatarsal bone, may be entirely absent (*Picoides*). A large sesamoid articulates with a special trochlea (intended for it) to the inner side of the fourth toe. The osseous claws usually large, and the other phalangeal joints more or less laterally compressed. The tendons of the leg sometimes ossify to a certain degree, and minute sesamoids may occur in certain tendons near the knee-joint.

Brief Remarks on the Probable Position of the Pici in the System, and their Affines.

Huxley in his "Celeomorphæ" comprehended only the *Picidæ* and *Inygidæ*, and Parker long ago said that "The 'Celeomorphæ' of Huxley form a most natural and well-defined group—a group equal zoölogically to the Pigeons or the Parrots. Evidently this differentiation has taken place through the gradual extinction, during long secular periods, of conjugational types more generalized than those now extant." In this much the present writer agrees with the two great authorities we have just quoted.

To those at all familiar with the osteology of existing birds it must be very evident that in this anatomical system, at least, the *Pici* hold many characters in common with the *Passeres*—a fact that will be evident when we come to treat of that group later on. It is my opinion that it is to the great Passerine group that the *Pici* are more nearly affined than to any other existing suborder of birds. One good genus of linking forms, at least, is the South

American *Picumnus*, as Parker has already shown, and Parker believed that the *Pici* "have a *Passerine* foundation."

I here venture to state that as our knowledge of the morphology of *Aves* becomes more perfect the fact will be appreciated that the *Pici* and the *Passeres* are divergent groups from a common stock in time; and that the former have simply become highly specialized and modified in accordance with their mode of life and habits. This common stock Fürbringer has referred to as the "Pico-Passeriformes," and the root-stock just prior to the divergence the "Pico-Passeres," which latter he again subdivides into his families. This also appears to be in keeping with our present knowledge of the subject and what osteology of the groups in question seems to indicate.

PHALLIC RITES AND INITIATION CEREMONIES OF THE SOUTH AUSTRALIAN ABORIGINES.

BY R. H. MATHEWS, L.S.
OF PARRAMATTA, NEW SOUTH WALES.

(*Read October 5, 1900.*)

This paper is intended as a continuation of the one I communicated to this Society in January last on *Divisions of the South Australian Aborigines;* and the map thereto appended, Plate VI, represents the territory within which the rites now described are in operation. Exigencies of space render it necessary to treat the subject in the briefest possible manner, but it is hoped that each part has been described with sufficient fullness to give a consecutive account of the proceedings.

It may, perhaps, be as well to state that I was appointed by the Government of South Australia a land surveyor in 1883 and a Justice of the Peace in 1884, both of which positions I still hold, by which means I have had opportunities which would not otherwise have occurred of carrying on my inquiries respecting the customs of the aborigines in that colony.

Circumcision.

When a tribe has a few boys old enough to go through this ordeal, messengers are dispatched by the head men to several of the neighboring tribes to ascertain if they also have some youths

ready for the ceremony. One of the lads to be operated upon whose body is painted with red ochre and grease, with down feathers in his hair, is sent with each messenger. The age at which the boys are circumcised varies from about eight to twelve years, depending upon the growth and development of the subject and other circumstances.

People occupying country a hundred or a hundred and fifty miles distant respond to an invitation of this kind, and assemble at a general camping ground which has been fixed upon by the initiator of the proceedings. The men of each tribe approach the main camp painted and in a meandering line, stamping their feet, and are accorded a formal reception by the local mob, after which they establish their quarters on the side nearest their own country. The boy who accompanied the messenger is borne into the general encampment on the shoulders of one of the men, and the old chiefs shout out the names of well-known localities in the district they have come from. They also mention flowering trees such as the wattle, remarkable mountains and shady trees.[1]

In a secluded place, a short distance from the main camp, a space about twenty-five or thirty yards in diameter is cleared of all grass and loose rubbish and partially surrounded by a fence of boughs, where the circumcision of the novices will be carried out later on. These gatherings are generally arranged to take place shortly after the new moon makes its appearance, so that there will be moonlight during some part of every night for two or three weeks; and where circumstances permit the summer time is chosen —the season of the year in which game and vegetable products are the most abundant being preferred.

Festive and preliminary ceremonials are carried on for some days after the last mob has arrived, which I need not now occupy the space to detail. While these performances are in progress the headmen assemble at their private meeting place near the camp, and determine the date on which the novices will be circumcised. As the men of one tribe circumcise the youths belonging to another, as soon as the date is announced the men of the several mobs present pretend to quarrel with each other, on account of their boys being compelled to submit to the rite. During the night considerable sexual intercourse is indulged in, but this privilege is accorded only to those persons who would be entitled to marry each other in con-

[1] *Proc. Roy. Soc. Victoria, N. S.*, Vol. x, pp. 4 and 32.

formity with the tribal laws, and would not be extended to the novices.

On the afternoon of the following day the youths to be operated upon are conducted to the prepared place before referred to and are kept there all night. When the men are taking the boys away, the mothers and other female relatives of the latter dance around and gently strike the men of their own phratry on the shoulder with the open hand. For example, the Koolpirro women would strike the Koolpirro men, and the Thinnawa women the Thinnawa men. After this the women retire, and are not permitted to witness any of the secret portions of the rites. The men who have the custody of the novices are accompanied by young fellows who were circumcised and subincised at previous gatherings of recent date.

A cold night is usually selected for taking charge of the boys, and they are kept at their camp without sleep or clothing. The men shove and pull them about to keep them awake, under pretence of watching for the approach of an enemy. At the first appearance of daylight a short passage is formed by some men standing in a row on one side and some on the other. During this time bull-roarers are sounded in the bush close at hand. A novice is carried along the passage referred to and laid face upward on the backs of several men who are clustered together, and his limbs are held fast. An old man, selected from one of the visiting tribes, then pulls the foreskin forward and cuts it off with a sharp flake of stone. The foreskin is then held up in view of those standing around and its appearance is hailed by acclamation. A new name is now conferred upon the graduate by which he will in future be distinguished. Those who have charge of him put dust or ashes on the wound to stop the bleeding. Being sleepy, cold and weary from the effects of the previous night's proceedings, his body appears to be numb and almost insensible to pain.

The same ritual is gone through in regard to every novice operated upon and a fresh circumcisor is appointed for each. These men profess to undertake their duty with reluctance, and are rubbed over with dust by their comrades before commencing the ceremony. Different ways of disposing of the foreskin are practiced in different parts of the territory treated of in this paper. In some districts it is eaten by the man who cuts it off and his friends, the men standing around being responsible that this is done. In other cases it is eaten by the elder brothers or brothers-in-law of the novice; in

others it is buried in sand or otherwise dealt with, according to the custom of the tribe in whose country the rite is carried out.

When all the subjects have been operated upon, they are placed standing beside their guardians, while two men sound bullroarers in their presence. Some armed warriors now advance in a menacing attitude and threaten the boys in fierce loud tones that if ever they divulge any part of the secret ceremonies to the women or to the uncircumcised, they will be punished with immediate death. About noon human blood is sprinkled over the bodies of the novitiates, and they are kept near the place where they were circumcised during the remainder of the day.

All the ceremonies being now at an end, toward evening there is another mock quarrel, and during the ensuing night the men of each tribe lend their wives to the men of the other tribes present; this privilege, however, is restricted to individuals belonging to the proper intermarrying divisions, and to men who have passed the prescribed initiatory rites. The following morning all the visiting tribes disperse and start on their return journey to their own hunting grounds, taking their respective novices with them.

Each tribe takes charge of its own novices, who are kept under the control of their sponsors after their return to their own country. They are taken away to a camp in the bush until their wounds are healed, during which period they must not be seen by women, and are restricted to certain kinds of food, in accordance with the directions of the old men. Several fires are now lighted to the windward of the graduates, so that they may be enveloped in a dense smoke, after which they are brought back by their guardians to a place previously arranged, where they are met by their mothers and female relatives, and are then taken to a camp near the single men's quarters. At the next meeting of the tribes for initiation purposes these young men will be permitted to be present at all the secret ceremonies which may take place.

C. Provis reports that "among the natives of Fowler's Bay, South Australia, after the boys were circumcised their hair was daubed with grease and clay and rolled into several divisions like rat's tails. A rounded pad composed of emu feathers, grease, clay and human excrement was then placed on top of the head and all the hair brought up over it and securely bound in its place."[1]

[1] *Folklore, Manners, etc., of South Australian Aborigines* (Adelaide, 1879), pp. 99, 100.

Subincision.

Splitting the lower side of the male sexual organ is denoted by a different word in each of the several communities among whom it is practiced. It will therefore prevent any confusion as to what is meant if we disregard the native nomenclature and substitute the English term *Subincision*, a name which has already been used by some writers and clearly indicates the character of the rite.

Some time after the wound caused by the circumcision has healed, the tribes are again brought together and the ceremony of subincision performed. The length of time between the two operations varies among different tribes, and is also subject to the convenience of mustering the people and other circumstances. The interval may be only a few months, or it may be a year or two, or perhaps several years. The age at which it is performed is entirely in the discretion of the old chiefs, and fluctuates from about fourteen to eighteen years.

All the preparatory arrangements are substantially the same as already stated in dealing with "circumcision;" and the proponents for initiation must be young fellows who have already submitted to that rite at previous gatherings. On the evening preceding the day fixed for the ceremony, the novices are taken to the appointed place near the camp, where they remain all night without clothing or rest of any kind. No youth who has not been subincised, nor any female, is allowed to see any part of this ceremony.

Early in the morning a novice is caught and thrown face upward on the backs of a heap of men, similar to that described in the circumcision ceremony, and held in position, a bullroarer being sounded by one of the men within hearing, but out of sight. In some cases a man sits astride his chest, so as to render movement of the body impossible. One of the assistants then takes hold of the youth's penis in his fingers and stretches it full length upward along the abdomen. He uses both hands in catching the glans—a hand on each side—and holds it in such a position as to expose the meatus and the urethral canal as fully as possible. The operator, who is chosen from among the strange tribes present, then with a sharp flint cuts the urethra open, extending the incision from the meatus toward the scrotum about two inches, and in some cases almost back to the scrotal pouch. In other districts the urethra is split from near the scrotum to within about an inch of the glans,

but leaving the head of the penis and the meatus uninjured. In the latter case the length of the cleft is from one to two inches or more.

The graduate is then released, and a piece of soft bark or a bundle of fur or down, greased with animal fat, is laid in the incision to keep it open. Wet clay or ashes moistened with a man's urine are also put in the wound to assist the healing. The organ is then bound round with string manufactured by the natives from the bark of a shrub or small tree bearing a yellow flower which grows in the sand hills.

As each youth passes through the ordeal he is placed standing on one side of the cleared space, and when the ceremony is concluded they are all congratulated by the men present, and the caution in regard to keeping the secret is again repeated. The young men are then taken away by their guardians into the bush, and when their wounds are healed they are brought back to a prepared spot in the vicinity of the camp and presented to the people of their tribe. This is done with certain formalities which need not now be entered upon, after which they are invested with the belt, the kilt, and other articles comprising the simple dress of an Australian savage.

During the ceremony of subincision—or at that of circumcision if the latter only is practiced—one or two men are killed and eaten by the visitors, who also drink the blood. The tribe in whose territory the circumcision or subincision has been carried out—these being the people who summoned their neighbors to attend the ceremonies—have to provide the person or persons thus sacrificed from among themselves. I also have evidence of this cannibalistic rite among the tribes occupying the eastern portion of Australia, where the initiation ceremonies take a different form.[1]

The Rev. C. W. Schürmann was the first author to accurately describe the mutilation of the penis among Australian tribes.[2] In 1846, when speaking of the Port Lincoln natives, South Australia, he states: "It consists of a cut from the orifice of the penis along its lower side down to the scrotum, thus laying the passage open in its whole length." In 1845, Mr. E. J. Eyre also reports having observed this peculiar custom in the same part of the country.[3] As

[1] PROC. AMER. PHILOS. SOC., Vol. xxxvii, p. 66.
Journ. Roy. Soc. N. S. Wales, Vol. xxxii, p. 250.

[2] *Aboriginal Tribes of Port Lincoln, South Australia* (Adelaide, 1846) p. 15.

[3] *Journs. Expeds. Discov. Central Aus.* (1845), Vol. ii, p. 332.

regards slitting a portion only of the urethral canal and leaving the head of the penis intact, a police trooper named Richards, in speaking of the natives of Fowler's Bay and Davenport Creek, South Australia, says: "An incision is made in the penis from near the testes to nearly the end."[1] C. Provis, a corporal in the police force, referring to the people near the same district, says: "An incision about half an inch long is made in the urethra between the scrotum and glans penis."[2]

Whether the incision is made from the meatus or there is only a perforation in the middle of the urethral canal in the way described, the subjects always afterward pass their water through the artificial opening. The men partially squat down during micturition and hold the penis horizontal with one hand. After the wound heals the urethra appears as a mere groove which becomes callous; and in those cases where the glans is split, the penis during erection becomes flatter and broader at the extremity than in its natural condition.

There is a widely spread opinion among laymen, and a few medical men have been found concurring in the same view, that the object of this rite is to prevent impregnation. I have made searching personal inquiries over an immense extent of country in Queensland, South Australia and Western Australia, and have collected incontestible evidence that men who have been operated upon in this way can be the fathers of families. Another equally erroneous popular belief is that some of the men are left intact for the purpose of propagating the race. Having carefully investigated this matter I am quite satisfied that in any case where such men have been observed they have been merely visitors from other tribes where the custom was not in force.

Scarring the Body.

Raising cicatrices by means of cutting on the back and chest is a custom of wide prevalence among the Australian aborigines, but more importance is attached to the ceremony in some districts than in others. From Cooper's Creek to the Great Australian Bight the rite may be briefly described as follows:

The subject is kept awake without food or clothing during a cold night, as in the two last described ceremonies, and in the morning,

[1] *Folklore, Manners, etc., S. A. Aborigines* (1879), p. 103.
[2] *Ibid.*, p. 99.

as soon as it is clear, blood is sprinkled over his body from the arms of some of the initiated and he is required to drink a small quantity, which must be that of a man older and stronger than himself. He is then laid on a heap of green bushes piled up on the ground to serve as a platform, where a man who is not a relative cuts certain lines on the back of his shoulders, on his chest and on the arms with a sharp flake of stone similar to that used in circumcision. The position and extent of the scarring is regulated by the custom of the tribe to which the novitiate belongs. During these proceedings the men standing around make a great noise. After this cutting, which is all done on the same day, a coat of ground charcoal mixed with grease is applied to his body, and he is kept at that place for two or three days.

He is then taken away into the scrubs by some initiated men who act as his guardians and provide him with food. He is not permitted to speak above a whisper, and firesticks are occasionally held close to the wounds to make them open and protrude as much as possible during the process of healing, in order to leave raised scars. Every evening about sundown he is freshly painted with a mixture of charcoal and grease on the arms, chest and face, the mixture being applied freely to the gashes in the flesh.

In the course of about six weeks preparations are made for returning the graduate to the tribe. He is now at liberty to go in quest of such articles of food as game, honey, roots and so on. Next he is painted with red ochre and grease on the lower parts of his body and on the hands and arms as far as the elbows. He is then taken to a spot near the main camp, where he is met and welcomed by the old men. A feast then takes place at which he contributes all the provisions he may have succeeded in obtaining, and gives presents to the men who participated in the ceremony of scarring his body.

As already stated, the youths are taken away from the women after they are circumcised, again when they are subincised, and again after their bodies are scarred. During these long sojourns in the bush with the old men they are permitted to see and listen to certain dances and songs, the secret lore of their forefathers and the traditional customs of the tribe. A mystic language or vocabulary is also inculcated, which is known only to those who have passed through the prescribed course of instruction. Every man and woman, all the animals, plants and surrounding

objects, as well as the principal places in their hunting grounds, have a secret name by which they are spoken of among the initiated, in addition to the general nomenclature with which the women and children are familiar. After the novitiates have passed through the final stages of the inaugural rites, the instruction thus briefly outlined is continued for many years at the single men's camp, at which the catechumens have now the right to be present.

In the portion of South Australia where subincision is not practiced the scarring takes place some time after the boys recover from the effects of circumcision. And in the districts where depilation is the initiatory rite, as in the Narrinyeri and adjacent tribes, the scarring succeeds that ceremony.

It not infrequently happens that after a batch of novices are circumcised, as described in earlier pages, and before the tribes disperse, such of the young men present who have passed through that ordeal at a previous meeting, and have attained a sufficient age, are seized by direction of the head-men and the rite of subincision performed upon them. This is done to save the delay and trouble of mustering the people again for the latter ceremony, in cases where the graduates are few in number.

It may be stated that the women, girls and little boys are forever afterward forbidden to go near any of the localities where the rites of circumcision, subincision or scarring have been carried out, these spots being rigorously tabooed to the uninitiated. This taboo extends to the initiated of a lower degree; for example, a circumcised youth could not enter upon a place where subincision had been performed, and so on.

Certain restrictions as to the food to be eaten by the novices at different periods of their course of instruction have to be complied with, in accordance with ancient custom, under the supervision of the old men.

Initiation of Women.

It may be stated generally that among all Australian tribes every girl on attaining puberty is violated, either in a natural way or by artificial means, before she is permitted to have a husband; this is a tribal law from which there is no escape. Among the people treated of in this paper it is found that certain mutilations are performed upon the young women by which the vaginal orifice is permanently enlarged.

When one or more girls have reached the requisite age, which is determined by the first menstrual flux and the development of the breasts, a meeting of the tribe takes place and some festivities are indulged in. The girls are taken by some old women a short distance from the camp, where they are met by men who take charge of them and conduct them to a place where everything is in readiness for the purpose. These men are *Noapa* to the novices—that is, they are men whom they could marry in accordance with the tribal laws. Here a girl is caught and placed lying face upward on the ground, and her hands and feet are held by the men present. An old man, appointed for this duty, then inserts two or three of his fingers, bound round with human hair, into the vaginal orifice for the purpose of stretching it. Sometimes a smooth piece of wood or stone, of the requisite thickness and length, is used to accomplish the same result. In either case the operation is continued until bleeding takes place. In other districts the lower part of the vaginal wall is lacerated with a sharp stone, the incision extending more or less into the perineum. Forcing a large body into the vagina in any of the ways just described causes a rupture of the fourchette, similar to that which usually takes place in the first parturition; and cutting with an edged stone effects the same purpose. Bleeding from the wound is arrested by plugging fur or birds' down into the passage. Shortly afterward all the men present, one after the other, avail themselves of their right of prelibation, or, as it is termed by the French anthropologists, *droit du culage*.

These mutilations, like those upon the men already referred to, are commonly supposed by Europeans to be done for the purpose of rendering the women incapable of bearing children, but I have gathered abundant evidence that there is no foundation whatever for this assumption.

Depilation.

This ceremony, the principal feature of which is plucking the hair from the bodies of the graduates, is practiced in the Narrinyeri and Booandik nations,[1] occupying the southeast corner of South Australia. As it is substantially the same as the *Kuranda* ceremony of some of the Barkunjee tribes, described in a paper contributed by me to the Royal Society of New South Wales in

[1] *The American Anthropologist*, Vol. xi, pp. 331–343, Plate V.

1898, it will be sufficient to give the following *résumé* from my previous work.[1]

The preliminaries connected with inviting the neighboring tribes and their assemblage at an appointed meeting place are almost identical with the practice of other districts. The time of life at which a youth is considered ready for the ordeal is determined by the first appearance of hair on the pubes and chin. On the morning of the day settled upon for the principal ceremony all the people are astir at daylight. The boys to be operated upon, who have been gathered out of the camp the previous night, are now painted all over with red ochre, their hair being combed and decorated with the white down of birds. When all is ready the guardians take charge of the novices, and a number of men armed with spears surround them in a circle, and all of them march away. The men make a great noise, shouting and beating their weapons together, but the boys remain silent, with their heads bowed toward their breasts.

The mothers of the novices and other women present make a pretence of resistance by throwing pieces of sticks over the heads of the men, but do not attempt to follow them. The men and graduates then proceed to a secluded locality previously agreed upon, perhaps some miles distant, where a camp is formed, and the novices placed lying down on a layer of leaves upon the ground, and are covered over with cloaks or grass, their guardians remaining with them. All the other men make their camp in close proximity. Between the quarters of the boys and those of the men a space is cleared of all sticks and grass, and a fire lighted close by it. In the evening, after the youths have partaken of their allowance of food, they are placed, sitting in a row, near this prepared spot, and the men go through various pantomimic performances, consisting of hunting and other scenes, imitating the animals which are the totems of those present, and certain obscene gesticulations which are usually practiced on similar occasions. Different burlesques take place every evening, and also sometimes during the day if the men are not otherwise occupied.

A week or more may be spent at these camping places in the bush, the time being regulated by the weather and other considerations. When conducting the novices from one camp to another they are obliged to hold a bunch of green boughs in each hand.

[1] *Journ. Roy. Soc. N. S. Wales*, Vol. xxxii, pp. 243–245, Plate XII.

During the afternoon of one or more of the days of this period the novitiates are carried a short distance from the camp, and placed lying down on bushes thickly strewn on the ground, and rugs spread over them. A man then sits down beside each novice, and commences pulling out the hair from the pubes, under the arms and the incipient beard; when one man gets tired he is replaced by another. Beeswax or gum is used upon the ends of the fingers to facilitate catching the hair, which is pulled out singly. The men of the novitiates' own tribe do not take part in the hair-plucking operation, this duty devolving upon the men of the different strange tribes present. The pluckers must be men who have been initiated in the same way at previous gatherings, and are the potential brothers-in-law of the novices who have been assigned to them. Some of the head-men of each tribe sit on the ground near by, directing the proceedings, and a bullroarer is sounded in the vicinity. The hair pulled out of the bodies of each youth is kept carefully by itself, and is given into the charge of one of his relatives, in the same way that the extracted tooth is disposed of in other districts. When the plucking of the hair has been completed the novices are raised to their feet by their guardians and other men, amid the shouts of all present. Each graduate is then painted and invested with the usual regalia of a man of the tribe.

The novices are then cautioned against divulging the details of what they have passed through to any person except the initiated. They are now taken to a place where the women have formed a new camp, where they are met by their mothers and other female relations, who light fires to the windward of them, enveloping them all in a dense smoke, caused by placing green grass, bushes or weeds on the burning wood. The graduates have to pass through this ordeal of depilation at not less than two or three different meetings of the tribes for that purpose before they can be admitted to full membership and be permitted to take a wife.

While the novitiates are going through their course of initiation in the bush with the old men they are shown the sacred bullroarer, and certain crystalline quartz stones which are supposed to protect, or in some way to confer magical powers upon, their possessor.

In the Narrinyeri, and in the Adjadurah nation adjoining them on the west, marriages are regulated by the old men in accordance with fixed rules. The sons and daughters of particular women are

allotted as husbands and wives respectively to the sons and daughters of certain other women, these matters being arranged during the infancy of the parties to the marriage, and in some cases before they are born. In order that every man and woman may be sure of obtaining a conjugal mate, several persons are appointed to each individual of either sex, the same persons being often eligible to several different people. When they all grow up to manhood and womanhood each man claims the woman who has been assigned to him, or, if she has died, he takes one of the other women who were appointed to meet such a contingency. In like manner, if the allotted husband of a young woman loses his life, she is taken by one of the other men provided for the purpose.

Miscellaneous Phallic Rites.

Besides the inaugural rites herein described, I am acquainted with other forms of initiation ceremonies in different parts of Australia, in all of which great prominence is given to the sexual organs. In aboriginal carvings of human beings on rocks and on trees, in raised or carved figures on the ground, and in paintings on the walls of caves, the sexual organs are conspicuously displayed. There is much in these rites and customs suggestive of the existence of some form of phallic worship at an earlier period, if not still actually observed, among the Australian aborigines.

In the great gatherings for the Bora ceremonies of the Kamilaroi community a gigantic horizontal image of Byama, a mythologic ancestor, is formed by heaping up loose earth upon the surface of the ground.[1] He is represented lying on his back, with a piece of wood cut into a representation of the human penis projecting from his abdomen. This organ is disproportionately large compared with the dimensions of the body. The initiated men assemble daily on the Bora ground and dance round this image, uttering guttural incantations and making remarks referring to the great size of the penis, and while so engaged they catch hold of their own genital organs in both hands. Similar representations have been observed by me among the Wiradjuri, Koombanggary and several other tribes.

Not far from the image of Byama is the earthen representation of his wife, also of colossal proportions and lying on her back,

[1] *Proc. Roy. Soc. Victoria*, Vol. ix, N. S., p. 144.

with the pudenda prominently exposed, around whom the men execute many libidinous dances.

On a Bora ground at Gundabloui, Moonie river, in addition to Byama and his female consort, there were the images of a man and woman lying together behind a tree [1] in the act of copulating. Similar shouting and dancing to that just described was indulged in around these figures.

Bora grounds always consist of two circles, defined by a low bank of loose earth, with a pathway connecting them, called *thoonburnga*, a word derived from *thoon*, the Kamilaroi name for the penis. The initiated men in going from one circle to the other walk along this track, which is supposed to represent the penis of Dharramoolan, a mystic evil being who is said to preside over the Bora ceremonies.

When the men assemble at the Bora circle and proclaim their totems, as described in my previous memoirs,[2] they also shout out the name of the penis. Certain localities in their territory are called by names made up from those of the genital organs of both sexes.[3] In many tribes the sacred bullroarer is rubbed upon the penis of every novitiate present at the inaugural rites.

During the secret portions of the ceremonies, the novitiates are placed sitting on bushes on the ground, with their hands clutching their genitals. The men place themselves in many obscene attitudes, in some cases fastening a piece of bark to the penis to give it the appearance of being of great length.[4] At other times they smear that organ with blood to make the boys believe that they have a menstrual flow, like the women. In some instances the men rub their penis on the food given to the novices; in others, they stand in front of the boys, displaying their genitalia, and invite them to take particular notice.[5]

In the pantomimic performances in the bush, in which the totems are represented, a man is hidden in a hollow place in the surface of the ground and covered over with leaves. When the men of the Kooringal presently turn him out of his lair—pretending to the novices that they think it is the nest of a gigantic bandi-

[1] *Journ. Anthrop. Inst.*, London, Vol. xxiv, p. 416.
[2] *Proc. Roy. Soc. Victoria*, Vol. x, N. S., p. 4.
[3] *American Anthropologist*, Washington, Vol. ii, N. S., p. 141.
[4] *Ibid.*, Vol. ix, N. S., p. 166.
[5] *Journ. Roy. Geog. Soc. Aust.*, Queensland Bch., Vol. xv.

PROC. AMER. PHILOS. SOC. XXXIX. 164. PP. PRINTED JAN. 19, 1901.

coot—they roll him over on his back and examine whether he is a buck or a doe.

Among all the aboriginal tribes with which I am acquainted masturbation and sodomy are practiced on certain occasions.[1] It is more general in the Kimberley district and Northern Territory than elsewhere reached by my inquiries, but I have traced them in the inaugural rites and ceremonial corrobories of the natives in all the Australian colonies.

In previous articles I have referred to the enactment of an obscene and disgusting tableau, called *Boballai*.[2] In several rehearsals of this tableau which I have witnessed there was no actual sodomy, but some of the old head-men present told me the vice was perpetrated in former times during this portion of the Bora ceremonies.

Mr. R. B. Smyth narrates a legend of the Victorian tribes which credits Boonjil, a traditionary ancestral chief, with micturating continually for several days upon the earth, the ample store of urine flowing away and forming the great sea.[3]

In the Dieyerie tribe the men obtained blood by wounding the penis for the purpose of fixing the down of birds upon their bodies at certain ceremonial dances. Mr. S. Gason[4] states that when the people of that tribe wish to make the wild fowl lay an abundant supply of eggs some of the able-bodied men sit in a circle, each having a bone from the leg of a kangaroo, sharpened at one end, with which they pierce the scrotum several times. . . . . They are generally laid up for two or three weeks afterward and are unable to walk.

Dr. E. C. Stirling, in describing the customs of some tribes in the Northern Territory, states that in some cases of severe illness the sick man is anointed all over with blood obtained by piercing the labia minora. The patient is held by several women while she, whose blood is being used, rubs it all over his body, after which a coating of grease is used. A sick woman may be similarly anointed with blood taken from the male urethra.[5]

[1] PROC. AMER. PHILOS. SOC., Vol. xxxix, p. 125.

[2] *Journ. Anthrop. Inst.*, London, Vol. xxv, pp. 333, 334.

[3] *Aborigines of Victoria* (Melbourne, 1878), Vol. i, p. 429.

[4] *The Dieyerie Tribe of Australian Aborigines* (Adelaide, 1874), p. 25.

[5] *Horn Expedition Central Australia*, Part iv, p. 182.

Both male and female urine is applied externally in several kinds of sickness, and is believed to be an excellent remedy. At the initiation ceremonies of many tribes the novices are made to drink the urine of the men, and also to eat human excrement.[1]

In several districts, when a boy reaches seven or eight years of age or upward and dies, his mother must submit to the plucking out of the hair of the pubes by the people of her own tribe.

Although the rites and customs described in the foregoing pages may appear very horrible to us, yet we should remember that the savage has been brought up amid similar scenes from his childhood, which causes him to view them in a different light from ours. To him they have all the sanctity and force of divine law; and any neglect on his part to conform to long-established custom would bring down upon him the hostility of the community, and subject him to all the retributive terrors of superstition.

Reference to the Map.

The map to which these references apply is Plate VI, accompanying my paper on the "Divisions of the South Australian Aborigines," published in No. 161 of the present volume of the Proceedings of this Society, pp. 78–93.

The region within which circumcision is performed, and also that in which the additional rite of subincision is practiced, are plainly delineated upon the map in question and fully explained in the letter-press at p. 93.

The map also shows the Narrinyeri nation, V, in which the rite of depilation or hair-plucking is in operation, which also extends into the part of the Booandik nation, VI, which is contiguous on the south.

Scarring the body is in vogue over the entire territory delineated on the map, but is carried out with greater ceremonial in some parts than in others.

Initiation of women is also practiced over all the country represented by the map, but the more rigorous forms of it, detailed in the letter-press, belong to the immense districts west and north of Port Augusta, reaching to the boundary of South Australia in both these directions.

In the northern part of the Kokatha nation, among the Hillary,

[1] *American Anthropologist*, Washington, Vol. ix, p. 339.

Kooyeeunna, Dieyerie, Ahminie, Wonkaoora, Wonkamudla, Yowerawarrika and Yanderawantha, the custom of extracting one or two of the front teeth is carried out, females being included in some of the tribes mentioned. In the remainder of the territory shown on the map the teeth are not interfered with.

Stated Meeting, October 19, 1900.

Vice-President SELLERS in the Chair.

Present, 20 members.

The death of Sir Henry W. Acland, Bart., K. C. B., at Oxford, England, on October 16, 1900, was announced.

Dr. J. Cheston Morris read an obituary notice of Dr. Henry Hartshorne.

The following papers were presented for the *Transactions:*

By Prof. C. L. Doolittle, on "Results of Observations Made at the Sayre Observatory, South Bethlehem, with the Zenith Telescope, from January 19, 1894, to August 19, 1895."

By Mr. O. P. Hay, on "The Chronological Distribution of the Elasmobranchs."

Mr. Rosengarten corrected an error in his paper, read before the Society April 6, 1900, entitled "American History from German Archives," and printed in Vol. XXXIX, No. 162, p. 129, etc., of its PROCEEDINGS, as follows:

It is there stated that "the Count of Zwei-Brücken (Deux-Ponts) published his *American Campaigns* in Paris in 1786, and his pamphlet was translated and reprinted by Dr. Green, of the Massachusetts Historical Society." The blunder of thus taking away from Dr. Green the credit due to him for the discovery and publication of the *Journal of Deux-Ponts* is inexcusable. Dr. Green published it in Boston in 1868, and in the Introduction tells the whole story: in June, 1867, he found the MS. *Journal* on a second-hand book-

stall in Paris, and he printed it, both in the original French and in an English translation, for the first time in Boston in 1868.

His notes, etc., give it a special interest and make it a valuable addition to contemporary records of our Revolutionary history.

To overlook this great merit and assign the printing of the *Journal of Deux-Ponts* to an unknown publication in Paris in 1781 is an inexcusable blunder. How it occurred it is difficult to explain—whether it was an error in the transcription of the real date of publication, 1868, and of the place as well as the time of printing, or a mistake for some other pamphlet, but it is now a simple duty to correct the error and to emphasize the fact that we owe the preservation of the *Deux-Ponts Journal* and its publication to Dr. Green and to him alone. It was not printed in Paris in 1786, nor anywhere at any time, until Dr. Green found it, rescued it and printed it in Boston in 1868, with a wealth of valuable material in the notes, etc., that could be gathered only by a ripe scholar thoroughly master of all the history of the period covered by the *Deux-Ponts Journal.* It is only one of a long series of valuable historical contributions made by Dr. Green, for both as a student and scholar and as the Secretary of the Massachusetts Historical Society, he has been one of the most intelligent and industrious collectors of original material for American history. To take away from such a man the credit due him for the preservation and publication of the *Deux-Ponts Journal* by a careless misprint and misstatement is a blunder that calls for an apology from the person who perpetrated the error; he therefore asks leave to print and put on record in the PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, where his mistake was put in print, this correction. Dr. Green is entitled to all the credit for finding, editing and printing the *Deux-Ponts Journal* in Boston in 1868.

The Society was adjourned by the presiding officer.

Stated Meeting, November 2, 1900.

Vice-President WISTAR in the Chair.

Present, 28 members.

Dr. Wharton Sinkler, a newly elected member, was presented to the Chair, and took his seat in the Society.

The Librarian laid upon the table a list of the donations to the Library, and thanks were ordered therefor.

The decease of the following members was announced:

Dr. Edward R. Squibb, at Brooklyn, on October 25, aged 81 years.

Rt. Hon. Friedrich Max-Müller, at Oxford, England, on October 28.

Dr. A. E. Kennelly made some remarks on "The Electrical Features and Novelties of the Paris Exposition," and Mr. Carl Herring spoke on the same subject.

Prof. Edwin Grant Conklin was elected a Councillor to fill the unexpired term of the late Dr. J. M. DaCosta.

The Society was adjourned by the presiding officer.

Stated Meeting, November 16, 1900.

Vice-President SELLERS in the Chair.

Present, 23 members.

Prof. E. W. Brown and Mr. Percival Lowell, newly elected members, were presented to the Chair and took their seats in the Society.

Letters were read from Hon. George Gray, of Wilmington, Del., accepting membership in the Society, and from Prof. E. G. Conklin accepting election as a Councillor.

The Librarian laid upon the table the list of donations to the Library, and thanks were ordered therefor.

Mr. Percival Lowell presented a paper upon "Evidence from Mars Upon the Cause of the Glacial Period," which was discussed by Profs. Doolittle, Snyder and Brown and Vice-President Sellers.

The Society was adjourned by the presiding officer.

MARS ON GLACIAL EPOCHS.

BY PERCIVAL LOWELL.

(*Read November 16, 1900.*)

1. Croll's ingenious theory that eccentricity of orbit combined with axial tilt produced our glacial periods challenges comparison outside the earth. And an example lies ready to its hand, in the planet Mars. For Mars not only presents appearances singularly suggestive of our polar snows, but stands so conditioned in eccentricity and tilt as to promise a criterion of a crucial character.

In consequence such appeal was very soon made and with the result of a seemingly complete denial. Although admirably circumstanced to exemplify the theory Mars did nothing of the sort. No marked preponderance of snow distinguished the hemisphere which glaciation should have covered. The ill-conditioned one showed as conclusive a snow-sheet as its fellow. Eccentricity apparently was powerless to effect vitally deposition about the pole.

This was more than a quarter of a century ago, and the last quarter of a century has revolutionized our ideas of the physical condition of Mars. Especially in the matter of water, we now have knowledge which has particular bearing upon the subject. We no longer believe Mars to be a counterpart of the earth. Among much that is analogous we see much that is the reverse; and with the flight of the similar the cogency of the argument departs. In the light of this change it becomes advisable to reopen the case; and I therefore make bold to introduce it to the notice of the Society.

2. Round about those parts of Mars which the motion of the markings point to as the planet's poles may be seen two roughly circular white patches, sharply contrasted with the other features of the disk. Each is fairly regular in shape, but changes in size according to what more particular inquiry shows to be the changing seasons of the planet's year. When the one patch is large the other is small; and as the one waxes the other wanes, the mass of white shifting from pole to pole with a certain chronometic cadence. Both appearances and behavior commended them to Sir William Herschel for polar snows, and such they have generally been considered since. Indeed the more minute our study of them, the more they seem to justify the imputation.

3. The obvious simplicity of this explanation, however, has tempted some ingenious minds to see in the exhibit not frozen water, but frozen carbonic acid gas. For under great stress of cold, carbonic acid not only takes refuge in the solid form, but does so with all the delicate purity of snow. The transformation demands, indeed, a very low temperature and to this end was the idea invented; inasmuch as the distance of Mars from the sun seems hard to reconcile with a mean temperature comparable to that of our earth. Now as it is of the first importance to the inquiry before us to be as certain as possible whether it be really snow or ice that we gaze upon over there in space, I make no circumstance of confronting at once this hypothesis.

Plausible as the suggestion of carbonic acid sounds, examination of the fitness of the substance for the place discloses one fatal defect. Carbonic acid and water agree well enough in their solid state and are not incompatible in their gaseous one, both being then invisible; but they are not at all at one upon their intermediate condition. As fluids their behavior is quite diverse, and Mars chances to exhibit the very effect which this diversity should cause. It is a peculiarity of carbonic acid that it is not at home as a liquid, passing, except under great pressure, at all temperatures practically instantaneously from the solid into the gaseous state. Under one atmosphere or less the curves representing the melting and the evaporation points of this substance lie almost side by side. And they do this as conclusively at very low temperatures as at relatively high ones. Carbonic acid insists on volatilizing. Thus no place is left in the economy of its behavior for a permanent liquid, whatever the degree of cold.

Now, one of the most striking features of the polar caps is the unmistakable exhibit of such a liquid. Seventy years ago, Beer and Mädler noticed a dark band surrounding the northern cap, but the full significance of the observation seems to have escaped deduction. Since then several observers have noted this band on one or other of the caps; and W. H. Pickering, in 1892, added a most significant detail, a large bay connected with the one about the southern cap. Farther study has brought out still more detail of the sort. Under this scrutiny the character of the phenomenon appears in so clear a light as to preclude mistaking its import.

The state of things seems to be this: So soon as either cap begins to shrink, there proceeds to surround it a blue belt. The belt in-

creases with the increased rate of diminution of the cap and decreases as that diminution falls off; meanwhile, it keeps pace with the cap, shrinking with it so as always to border its outer edge.

It is difficult to conceive how anything could more conclusively proclaim itself the liquid product of the disintegration of the cap. This badge of blue ribbon seems to mark the substance as H_2O.

4. Against this pronounced appearance and decisive conduct on the part of the cap, what difficulties have we to oppose to its acceptance for what it purports to be? Two such present themselves, both on the score of general temperature: first, the less heat received by the planet due to its greater distance from the sun, a heat only the moiety of what falls to our lot; secondly, a thinner air at the surface than that we know, perhaps in amount but a seventh that of our own. Are either of these objections fatal? Upon scrutiny I think we shall see that neither of them necessarily is so, on account of certain counterbalancing facts.

5. In the first place, not all the heat intercepted by the earth reaches its surface which might do so, quite apart from what is necessarily reflected. From the commotional character of our sky, it is safe to say that the earth fails of half the heat it would receive were that sky perfectly clear. What with storms, passing clouds and haze, fully more bar than passage is offered to the rays. Now the Martian sky is clear, perpetually so. All the heat a pure sky permits of passage falls unhindered upon the soil. Its frugal atmosphere wastes nothing. Thus receptivity makes up what distance denies.

6. As regards the second point, it used to be thought that air, pure and simple, furnished the earth with the cloak that kept out the cold of space. But it is no longer considered thus effective. Tyndall made experiments on the subject to the deduction that not air, but water vapor it was that did the business. Since then the enormous preponderance of power ascribed by him to water vapor has been questioned; but experiments to disprove it labor under the disquieting impossibility of excluding the vapor itself from the test. To get perfectly dry air is as difficult as to get a perfect vacuum; and the least trace of water vapor is potent to vitiate the whole transaction.

As figures are here of importance I shall quote him on the subject. In his "Rede" lecture at Cambridge, in 1867, Tyndall says:

"Compared with the great body of the air, the aqueous vapor it contains is of almost infinitesimal amount, 99½ out of every 100 parts of the atmosphere being composed of oxygen and nitrogen. In the absence of experiment, we should never think of ascribing to this scant and varying constituent any important influence on terrestrial radiation; yet its influence is far more potent than that of the great body of the air. To say that on a day of average humidity in England the atmospheric vapor exerts one hundred times the action of the air itself, would certainly be an understatement of the fact; . . . . and I am not prepared to say that the absorption by this substance is not two hundred times that of the air in which it is diffused."

And below he goes on:

"Probably a column of ordinary air ten feet long would intercept from ten to fifteen per cent. of the heat radiated from an obscure source, and I think it certain that the larger of these numbers fails to express the absorption of the terrestrial rays effected within ten feet of the earth's surface."

But England has a very moist climate. If, then, the trace of vapor there be but the $\frac{1}{200}$ part of the whole, much less must it be elsewhere. If we call it one $\frac{1}{500}$ part of the main body of the air, in the drier regions of the earth, and consider the Martian atmosphere at the surface of the planet to be one-seventh of our own at sea level, the vapor tension might be as great as ours and yet the total amount of vapor present but $\frac{1}{70}$ of the whole atmosphere. In which case it would render that air as effective a covering as our own. I am far from saying that this is the case; the more so that, as we shall presently see, there are local conditions which, in the event of its being as copious as, would render it much more effective than, our own. But it is worth noting how little we need go out of our way in possibilities to furnish Mars with sufficient covering.

7. While we are on the subject of carbonic acid, we may note that that gas shows, unlike water vapor, remarkable exclusiveness in the absorption of heat. Ängstrom finds its absorption belt in the spectrum very circumscribed, and in the lecture quoted above Tyndall tells us that practically it absorbs no heat but what radiates from carbonic acid itself. Such domesticity limits its absorptive efficiency in the world at large. The result of which is that there would be a tendency to equalize its deposit over the whole planet; for the surface covered by carbonic acid snow would

be kept warmer and the surface bare of it colder than each otherwise would be until carbonic acid was deposited over the whole.

8. From the foregoing it is clear that the amount of moisture consonant with temperate conditions upon the planet does not require to be great. We need, therefore, feel no surprise that spectroscopy should as yet give us uncertain answer on the subject. Huggins found marks of the presence of water vapor in the planet's spectrum; Campbell could find none. And the latter thought he should have done so had the amount been so much as one-fourth of our own.

But there is another drawback to this deduction. It is possible to point out a fallacy in the assumption of the data upon which the detection depends. We are told that the light examined has passed twice through the Martian atmosphere. But this is not the fact. A part of it has done so indeed, but only a part. A considerable portion has never traversed that atmosphere at all. We should know *à priori* that this could not but be the case. But we are not left to *à priori* reasoning in the matter. We have direct evidence of the fact. One of the peculiar details of the disk the planet shows us is the presence over a part of it of a veil which is not only unmistakable but pronounced. This veil is known as the limb-light. Extending in from the limb along its whole length is a brilliance strong enough to swamp all but the heaviest markings for a distance in of thirty degrees. Circumstances of position show that this can only be the effect of an atmosphere (*Annals Lowell Observatory*, Vol. I). It must extend over the whole disk, but becomes conspicuous only as we approach the limb, owing to the greater depth of it passed through as we increase the inclination. It should vary roughly, though not exactly, as the cosecant of the angle in from the limb. The effect might be due to anything suspended in the air—dust or water vapor. It does not seem possible as yet to evaluate it satisfactorily, but from its action it would appear to bear no inconsiderable ratio to the rest of the illumination. Suppose this ratio to be one of equality—and the amount of obscuration it effects show this to be no unseemly supposition—then its presence would halve the precision, and instead of being able to detect a quantity one-fourth of our own, we should only be able to perceive the double of that.

9. Now, whatever moisture there be on Mars—and water there must be to some extent, since otherwise no seasonal change could

occur, and that such change does take place is an indisputable fact of observation—such moisture would be rendered more potent there than it is on the earth by two Martian specialties in the matter of climate: first, the condition of the sky by day and, second, the state of the sky by night.

The day-sky on Mars is distinguished by being almost perpetually clear. From dawn to dusk daily and from the year's beginning to its close, the sun shines down upon the planet's surface out of a heaven unflecked by cloud. I have mentioned this above, but one deduction from it I want to bring forward more prominently. Not only does a clear sky give ingress to warmth by the absence of cloud, but if it contain water vapor it plays in addition the part of cloud itself. It exerts the efficiency of cloud and the efficiency of sunshine combined. For it lets in the warmth and then will not let it out again. In short, this transparent moisture suspended in mid-air is as a glass to make of the planet a conservatory. And when we reflect that this is true all over the planet at all times, we see that even the chief disturber of such a state of heat accumulation, the influx of cold winds from elsewhere, is as much as possible stopped.

The importance of this solidarity in fair weather climate can hardly be overestimated. It is the indraught of colder winds that thwarts that hothouse heightening of the temperature which we experience in the days called weather-breeders. It is true that the coldness of the incoming winds is consequent on many causes, and universal sunshine would not avail to prevent a fall of temperature due to such circulation; but a general heating of the ground, especially to the northward, would certainly temper its effects, not so much by equalizing the extremes, if indeed it would do this at all, as by raising the means.

10. The night-sky on the planet abets the action of the day one. Just as the day sky is cloudless so the night-sky apparently is cloudy. This is the outcome of Mr. Douglass' study of projections upon the terminator. By first observing and then classifying over four hundred of such projections, he came to the conclusion that the appearances could not be produced by bodies contiguous with the planet's surface. In other words, the optical effects were not such as could be caused by mountains, but were such as could be caused by cloud. Thus interpreted he finds that, though the sky is fleckless all day, at sunset clouds begin to form, showing their presence by

the way in which they are lit up into the night after the sun has set to the ground below. In like semblance of beacons he finds them out beyond the sunrise terminator, heralds of the dawn.

Whether the cloud canopy has been continuous the night long we cannot of course positively affirm. That it has been so seems probable, inasmuch as the conditions which caused it to form would continue to some extent on through the night. The surface would grow colder and colder, thus keeping up the condensation into cloud above it. And this state of things would last till sunrise, as the coldest moment, so far as the heat received from the sun goes, is the moment before the dawn. That at that time we find the clouds still there is strong presumption that they have not left their posts during the night. The effect of such a cloud canopy to the planet during the night hours is as important as the lack of it was important by day. It effectually shields the surface from depleting radiation. It thus helps husband what the day garnered of heat. It acts again the part of the glass in a greenhouse.

11. So much on the score of authenticity of appearance presented by the Martian polar caps—so much, that is, toward the establishing that they are what they purport to be.

From the constitution of the caps we pass now to the second point in which the planet recalls our own for purposes of glaciation, to wit: in the character of its orbit. The caps show us apparently that the necessary material is present; the orbit assures us that the necessary cosmic conditions are fulfilled.

At the present time the orbit of Mars is possessed of an eccentricity about five and a half times our own. Our earth's is .0168; that of Mars .0933. The planet's axial tilt, too, is consonant with the conditions of a criterion; for it is closely accordant with the earth's. According to Schiaparelli, who has made the last and undoubtedly the best determination of this tilt, the planet's equator is inclined to its ecliptic 24° 52′. That is 25°—for the quantity cannot be found to within the nicety of a few minutes—represents on Mars what $23\frac{1}{2}^{\circ}$ does on the earth, the tilt of the planet's poles and the consequent breadth of its arctic regions. The slight difference between the two values would simply increase by so much the theoretical effect of the eccentricity.

We have then in the case of Mars at the present moment both eccentricity and tilt, such as to enhance whatever effect might be expected. For by an odd coincidence it so chances that these essen-

tials are circumstanced nearly the same. In both planets the solstices fall not far from the line of apsides. What is more, it is the same solstice that occurs near perihelion in each case. Mars comes to perihelion in longitude 153° 4′ and to the summer solstice of his northern hemisphere in longitude 176° 48′; our earth reaches the like points in her orbit, the perihelion in longitude 281° 21′, the summer solstice of her northern hemisphere in longitude 270° 14′ respectively. Thus both planets pass those points, whose near coincidence is vital to the effective working of the eccentricity, in close succession. With Mars the summer solstice follows perihelion; with the earth it precedes it. This has the effect in the northern hemisphere of clipping the Martian beginning of summer as compared with its end, and of curtailing the mundane end of it as compared with its beginning; similarly in the southern hemisphere of both with regard to winter.

Curious it is that both planets should turn to the sun their corresponding hemispheres correspondingly—an agreement in inclination which permits of paralleling, by what may at the moment be discerned on Mars, what would happen on the earth during an accentuation of eccentricity such as is invoked to account for a glacial period. It would show itself, too, under magnification. For the greatest maximum possible to the earth's eccentricity is, according to Leverrier, .0747, or a fifth part less than that of Mars now.

21. Having surveyed the situation, material and mechanical, we may now turn to the phenomena. When we do so we are confronted at once upon the planet by what appear to be unmistakable polar caps, fairly comparable with our own in size and behavior, but with a difference. Ours are first distinguished by their greater extension. In our northern hemisphere the ground in winter is covered by a permanent mantle of snow down to about latitude 45°. This represents our snow-cap at that season, as it would appear to an outsider. In this we live and move and have our being for some four months, and it is at least a pregnant thought that to such an outsider the highest development of life upon our planet should seem thus for nearly half the year to have its existence within the polar cap. It opens our eyes, abstractly as well as personally, thus for a moment to see ourselves as others see us. Our northern polar snow-cap, then, covers on the average round the globe 90° or more at its most. If we take occasional snowfalls into account the maximum might be considerably stretched; for snow sometimes not only

falls but lies below latitude 35° both in America and Asia, and if our sky were clear, as that of Mars is, would be distinctly perceived by an onlooker as part, even if a detached part, of the polar cap. From its maximum the cap then dwindles till at its least, about two months after the summer solstice, it has so shrunk as to measure only about 40° across.

With regard to our southern cap, it is not possible to affirm so positively either the maximum or the minimum because of the presence there of surrounding oceans. Nevertheless it is apparent, from the greater cold of corresponding southern latitudes, that at its greatest the cap would exceed its northern fellow if duly given ground; while the summer glaciers of Terra del Fuego show that it would probably be the greater of the two at its minimum as well.

Now on Mars the northern cap attains at its height a width of 70°, which event occurs about one hundred of our days, or fifty-three of its own, after its winter solstice. About the middle of February this date corresponds to on earth. It then decreases regularly to its minimum, which takes place about the same time after its summer solstice. Near the minimum it remains some time. At this, its smallest compass, it measures only some 3° across.

Confining ourselves now for the moment to what we can directly compare, the northern caps of the two planets, we find a difference in relative size between them at both their extremes in the same direction. That of the earth is bigger than that of Mars, both at maximum and at minimum. As to the maximum, this happens in spite of the fact that the Martian year, and therefore the Martian winter, is nearly twice as long as our own, so that for nearly double the time any given northern latitude there is tilted away from the sun.

This is not all. If we express analytically the area of a zone embracing the pole of given breadth in degrees θ, we find for its value

$$\int_{\theta=0}^{\theta=\theta}\int_{\phi=0}^{\phi=2\pi} r^2 \sin\theta \, d\theta . \delta\phi$$

Where r is the radius of the sphere, φ the azimuth and θ the polar distance,

$$= -2\pi r^2 \cos\theta \Big|_{\theta=0}^{\theta=\theta} = 2\pi r^2 (1-\cos\theta)$$

From this we see that the maxima and minima on the earth are as five to one; while on Mars they are as 130 to one. The ratio of decrease due to summer melting is then twenty-six times as great in the latter case as in the former.

To the belief that Mars lacks warmth this comparison is calculated to give a shock of surprise. But however that be, we come next to an even more unexpected result.

13. This next feature is the difference in behavior of the two caps. At its greatest the southern cap surpasses the northern one; at its least it falls below it, passing it the other way.

It is both bigger in winter and smaller in summer than its northern counterpart. It thus outdoes its fellow in action generally—in accumulation first, in dissipation afterward. Beer and Mädler stated this long ago, though curiously enough upon quite erroneous data. Surprising as the circumstance is—for it becomes more surprising on consideration—I think it can be shown to be the fact.

In the case of the maxima direct data on the point are lacking. The maxima are not easy to determine, owing to the tilt of the axis and the fact that the solstices occur nearly at the apsides, and they never have been determined. We have, with two exceptions, only determinations made a long way one side or the other of the date of the maximum. One of these exceptions was that of Sir William Herschel, made six months before its summer solstice, and therefore about 145 days after its winter one. In 1781 he estimated the diameter of the southern cap at 60°.

In 1798 Schroeter made it 50° four months before the summer solstice. While Mädler in 1837, at the time of the winter solstice, estimated it at 70°. It is quite possible that he mistook some of the southern islands for the cap, a mistake made by more than one observer. No further approach to a maximum is recorded till Schiaparelli observed that of 1882, 150 days before the summer solstice, at 45°. All of these were too far away from the true time of the maximum to give even approximations of it.

The second exception was the determination made at Flagstaff in 1896–97 on the north pole, of which a transcript follows. The extent of the cap has been got by taking its width from the figure (*Annals Lowell Observatory*, Vol. ii, page 232) between two given dates; and the number of days before the solstice has been put as the mean of these two dates.

Width of Cap.					*Days after winter solstice.*	*Days before summer solstice.*
Jan.	11–Jan.	25	50°	Jan.	48	
	17– "	28	47		55	
	31–Feb.	10	60	Feb.	78	
Feb.	6– "	17	72	"	90	
	13– "	21	71	"	100	260
(Mar.	22–Mar.	30	77	Mar.	174)	
	23– "	31	73		177	183
	26–Apr.	4	72	"	182	178
	29– "	7	63	Apr.	188	172
Apr.	1– "	11	63	"	197	163
	13– "	20	58	"	218	142
	16– "	26	49	"	230	130
	24–May	2	51	"	245	114
May	26–June	4	22			43
	28– "	6	18			39

It will be seen from this that we have but two determinations at all to the point—those of 1781 and 1897—and neither of these as definite as is desirable.

That the maxima apparently occur about one hundred days after the winter solstices of their respective hemispheres we can gather from the observed times of the minima, of which we know very much more. But we can only surmise this, subject to future correction.

Although the direct data are thus inconclusive on the subject of relative size, there are, however, what we may call indirect data in the case. If we compare the two caps at corresponding periods before the time of solstice we shall get a fair idea of their state midway in their career. And for this comparison we do possess very respectable data, since at this stage both caps have been fairly often and fairly well observed. Tabulating all the records from ninety-two days before to thirty days before their respective summer solstices for the two caps, we have the following list:

PROC. AMER. PHILOS. SOC. XXXIX. 164. QQ. PRINTED JAN. 19, 1901.

South Cap.				North Cap.			
Days before summer solstice.		*Size.*		*Days before summer solstice.*		*Size.*	
1862	48	36°	Lord Rosse	1882	82	20°	Schiaparelli
1877	34	29°	Schiaparelli		77	27°	
1890	63	30°	"	1884	84	30°	
	55	25°			76	28°	
	48	25°			65	25°	"
	35	20°	"		55	25°	
1894	89	50°	Lowell Obsy.		46	22°	
	76	39°			35	25°	
	69	37°		1886	85	30°	
	52	31°			55	21°	"
	44	25°			32	12°	(mean)
	42	13°					
	33	27°		1897	43	22°	Lowell Obsy.
					39	18°	
				1899	92	40°	Flammarion & Antoniadi
					77	35°	
					75	36°	
					58	33°	
					41	30°	

Days before summer solstice.	South Cap. *Mean.*	North Cap. *Mean.*
92–80	50°	30°
80–70	39	32
70–60	34	25
60–50	28	26
50–40	25	25
40–30	27	18

From this it appears that from ninety-two days to thirty days before their respective summer solstices the southern cap is continuously larger than the northern one. Furthermore, that it exceeds the latter most the farther away it is from the solstice. From which we may conclude that at its maximum it also surpassed the latter.

Any correction for irradiation would but increase the contrast, since the north polar cap is necessarily observed from a much

greater distance than the southern one when seen thus near its summer solstice; and the irradiation being the same for both in seconds of arc becomes, with decreased size of disk, greater as measured in Martian degrees.

14. As a preliminary to an explanation of this phenomenon, it is necessary to consider the general laws of planetary insolation, or, in other words, the amount of heat received from the sun by different parts of the planet at different times.

The total quantity of heat intercepted by the planet as a whole in passing from any point of its orbit round to the same point again is a function of the eccentricity of the orbit. For heat or light, like gravity, diminishes inversely as the square of the distance. But the quantity of gravity received, if we may so express ourselves, is measured as follows:

Since equal areas are swept out by the radius vector in equal times, or $r^2\, d\theta = h dt$; and since $cg_1 = \frac{1}{r^2}$

$$c.\ h.\ dt.\ g_1 = d\theta$$

or

$$h\ C.\ G. = 2\pi$$

where $G =$ total gravity received during a revolution. Now if the major axis of two orbits be the same, the period is the same. Consequently in this case G varies inversely with h. But

$$h = \sqrt{\mu a\,(1-e)^2}$$

whence

$$ah^2 = \mu b^2$$

$$h = \frac{b\sqrt{\mu}}{\sqrt{a}}$$

Whence the total gravity and consequently the total heat received varies inversely as the minor axis of the orbit, and is therefore a function of the eccentricity.

15. But the relative amount received in passing from one equinox to the other does not vary but is the same, as D'Alembert showed, from whichever equinox we set out. That is, the planet has as many units of caloric fall upon it in traveling from the vernal to the autumnal equinox as from the autumnal to the vernal one. Indeed, whatever point we are pleased to take for starting point,

180° journey out will see as many calories reach it as the subsequent journey of 180° in. For

$$r^2 \, d\theta = h dt.$$

whence

$$d\theta = \frac{h \, dt}{r^2}$$

That is the angle swept over is at all points proportional to the amount of heat received, since this amount is always inversely as the square of the radius vector.

16. Thus the heat received through any angle is independent of the eccentricity. But it is not independent of the axial tilt. The amount of heat received at any point, in consequence of the tilt, depends upon the position of the point. At the pole it varies from nothing for the six months about the winter solstice to

$$\int \frac{1}{r^2} \sin \delta . \, dt = \int \frac{\sin \theta \sin \epsilon . \, d\theta}{h}$$

for the other six about the summer one.

For a hemisphere, taken as a whole, the total summer insolation much exceeds the winter one (Weiner, Ueber die Stärke der Bestrahlung, *Zeitschrift der Oesterreichischein Gesellschaft für Meteorologie*, 1879; also Sir Robert Ball, *The Cause of an Ice Age*, 1892).

Let $2H$ be the amount of heat falling on a section equal to the earth at unit distance in unit time, and let δ be the declination of the sun.

Then the amount received by one hemisphere at distance r in the time dt will be

$$\frac{H}{r^2} (1 + \sin \delta) \, dt$$

and by the other

$$\frac{H}{r^2} (1 - \sin \delta) \, dt$$

but

$$r^2 \, d\theta = h dt$$

whence the above

$$\frac{H}{r^2} (1 + \sin \delta) \, dt$$

$$= \frac{H}{h} (1 + \sin \delta) \, d\theta$$

again, since $\sin \delta = \sin \theta \sin \varepsilon$, where $\varepsilon =$ obliquity of the ecliptic the above becomes from equinox to equinox

$$\int_0^{\pi} \frac{H}{h}(1 + \sin \varepsilon \sin \theta)\, d\theta = \frac{H}{h}(\pi + 2 \sin \varepsilon)$$

and for the other hemisphere

$$\frac{H}{h}(\pi - 2 \sin \varepsilon)$$

With $\varepsilon = 24^\circ\ 52'$, the present received value on Mars, we have the two in the proportion of 63 to 37.

But though the summer and winter insolation thus differ, they are the same for each hemisphere in turn. Consequently the above cannot be the cause of the differences in question between the respective maxima and minima of the polar caps.

17. Not the amount of heat but the manner of its reception, then, is responsible for the difference we observe. Looking at it in this light we shall detect certain diversities of position competent possibly to the result.

Of the opposite variations presented to us by the two caps, the one most difficult to detect is the easiest to explain. The difference in the maxima seems to be due to the surpassing length of the antartic night.

Owing to the eccentricity of the orbital ellipse and the position of the solstices, the southern hemisphere is both farther away from the sun during its winter and is so for a longer time. The arctic polar night is 306 of our days long; the antarctic 381. Thus for seventy-five more days than happens to its fellow, the southern pole never sees the sun. Now since the total sunlight from equinox to equinox is the same in both hemispheres, its distribution by days is different. In the northern hemisphere the same amount is crowded into a smaller compass in the proportion of 381 to 306; that being that hemisphere's relative ratio of days. But since, during the winter, there is a balance of accumulation over dissipation of snow, each twenty-four hours must on the average add its tithe to the sum total. The northern days, being the warmer, each add less than the southern ones; and furthermore there are fewer of them. On both these scores the integral of the additions about the northern pole is less than about the southern one. Consequently the snow sheet is there the less developed.

18. With the minima the action is otherwise. Inasmuch as the greater heat received during the daylight hours by the southern hemisphere is exactly offset by the shortness of its season, it would seem at first as if there could be no difference in the total effect upon the two ice-caps.

But further consideration shows a couple of factors which might, and possibly do, come in to qualify the effect. One is that the diurnal heat, being more intense though not so long continued, might work to more advantage. For the water would be the more likely to flow away the greater was the quantity of it manufactured; or if it were caught up into the air more of it would be wafted away beyond reach of refreezing. It is the freshly acquired mobility that does the business. As ice the substance is chained to the spot; as water or vapor it is free to roam; and natural conditions at once transport it out of the region and so out of the problem.

The second factor is due to the action of the intervening nights. The vapor set free during the hours of sunshine is not all deposited during the night, as is witnessed by the presence of sunrise clouds. Such part as is not precipitated forms a blanket for the ground, preventing the heat of the surface from being radiated off into space. The greater the evaporation during the day the denser, other things equal, would be the cover-lid at night and thus the less heat be permitted to escape. This saving of heat is just so much to the good in the struggle of relative dissipation on the side of the southern hemisphere. The next day does not find so much to undo before it can make its own advance. Thus the whole effect in melting the snow would be greater upon that hemisphere whose summer happens to be the more intense.

19. It would appear then that on Mars not only has the eccentricity no tendency to foster the retention of an extensive ice-cap about the pole of that hemisphere which has its summer solstice near perihelion, but that the permanent accumulation there is actually less than at the opposite pole.

20. Now suppose the total deposit of ice in winter to increase. Call

a, the southern cap at its maximum.

b, the same at its minimum.

a_1 and b_1 the respective maximum and minimum for the northern cap.

x the increased ratio of deposition, where $x > 1$: then

$a - b$ equals the amount of the southern cap melted during the summer.

$a_1 - b_1$ equals the same for the northern cap.

$xa - (a - b)$ will then represent the size of the southern cap at its new minimum, and

$\frac{xa - (a - b)}{b}$ or $\frac{(x - 1)\, a + b}{b}$ will be the ratio of the old minimum to the new. The ratio of the old maximun to the new is $\frac{xa}{a}$ or x

Now $\frac{(x - 1)\, a + b}{b} > x$, for if it were equal to it we should have

$(x - 1)\, a + b = bx$;

whence $(x - 1)\, a = (x - 1)\, b$ and since $a > b$ the first member would exceed the second.

Thus the minimum would increase at a faster rate than the maximum with increased deposit.

For the northern cap we have similarly

$$\frac{(x - 1)\, a_1 + b_1}{b_1}$$

The similarity of the expressions shows that the same result would hold here too.

But furthermore we have for the ratio of the maximum–minimum ratio of increase in the two caps respectively :

$$\frac{(x - 1)\, a + b}{b} \quad \text{to} \quad \frac{(x - 1)\, a_1 + b_1}{b_1}$$

The first member exceeds the second, for

$$\frac{(x - 1)\, a}{b} + 1 > \frac{(x - 1)\, a_1 + b_1}{b_1}$$

Since

$$\frac{a}{b} > \frac{a_1}{b_1}$$

So that the minimum increases relatively to the maximum faster in the southern hemisphere than in the northern one. And as this relative increase never changes sign, as the precipitation increases a time must come when the southern minimum will actually exceed the northern one in size and do so more and more, indefinitely.

Whence we find ourselves facing the interesting conclusion that with precipitation increased equally over the whole planet the size of the perpetual ice-cap at the southern pole would finally surpass that about the northern one. Whereas, then, with moderate precipitation the hemisphere with the extremes of summer and winter climate would have the less perpetual ice of the two; with more precipitation the result would be reversed.

21. On the earth this greater precipitation is made possible by the greater amount of water on the surface. Thus a glacial period might be produced with us under the very same conditions which would bar it on Mars. It would come about in consequence of the eccentricity of the orbit, but not chiefly because of that eccentricity. Rather, we may say, because of the amount of moisture capable of being manufactured. For were the moisture to fall below a definite amount, not only would no glacial period result no matter what the eccentricity, but actually a sort of anti-glacial epoch would be brought about by that very same cause.

Croll distinctly emphasizes the fact that it is the indirect not the direct effect of the eccentricity that causes a glacial period. This indirect effect he follows through increased precipitation to change of the winds and lastly to change of oceanic currents. What the present study of the problem appears to point out is that increased precipitation alone, from any cause whatever, is competent to the task.

22. Here, then, we have a remarkable reversal in arctic conditions from glacial to something not unakin to its opposite, due directly, not to change in eccentricity, though it presupposes eccentricity in the process, but to a greater or less abundance of water. And water plays a part in the performance of this act in each of its three forms—as gas, as liquid and as solid. As a gas, the lesser amount of it—for I believe it to be less in amount on Mars than with us, though relatively to the other two states of the substance greater—acts to keep the day-sky clear, the night-sky cloudy, and thus to foster the summer melting which results in a diminution of permanent ice. As a liquid, in which state it is certainly much scarcer

than with us, its relative absence causes a dearth of deposition which is the most important factor in establishing the conditions we have seen to exist. Lastly as a solid, the comparative lack of permanent ice-fields tends to keep the climate in a relatively genial condition and thus to allow the other two forms the greater play. Though the last seems but a passive partner, an acquiescer more than active accomplice, its *rôle* is not the least vital of the three. There is no doubt that the climate of our own arctic and antarctic regions is boreal to an extent far surpassing what mere absence of sun could cause. It is the storage of ice, the actual cold locked up in that substance in those polar prisons that is the true climatic controller of the extreme north and the extreme south.

23. From the mode of melting of the Martian polar caps, it is clear that we could have predicted a general dearth of bodies of water upon the planet from that evidence alone. We ought to have seen that so much was unmistakably written in the record open to our inspection. But other evidence presented itself first. So that we were already in possession of decisive testimony before the polar phenomena got a hearing.

Already we had come to the conclusion that what were formerly thought to be oceans, the-blue green markings, were not in reality seas, but vast tracts of field or forest. Many things testified to this; but not to weaken the argument by multiplying the proofs, it may suffice to say that permanent dark lines traverse them, and coincidently traverse the idea that they can be seas. At the same time they change color with the season, as vegetation would do. As autumn advances they fade from green to gold, and with the spring grow green again. Our own forests could look no other viewed across the millions of miles of separating space.

Change implies air, and vegetal change water to boot. Thus there is some water on Mars, though there is not much.

24. After the phenomena of the maxima and minima of the caps, the next peculiarity connected with them is the eccentring of the southern one. And this distinction is the more significant from its not being shared by the northern. The northern cap sits squarely upon its pole. The southern, on the other hand, is markedly eccentric to the axis of rotation. Its centre lies some seven degrees from the geographical pole over toward a point in about longitude 54°. Since then the two do not agree to differ, but are each idiosyncratic, it is clear that the cause cannot be one common to

both, but must consist in some peculiarity of the southern cap. Furthermore it must be some very general condition, for the eccentring is not confined to any one era or stage in the existence of the cap. It is observable from the time the cap is at its widest to the supreme moment of its decay. Nor does it shift its place to any extent throughout the shrinking, till the cap's size becomes so small that a trifling preponderance here or there in longevity unduly expresses itself in longitude. Such constancy of position shows that the whole accumulation is eccentrically placed, and not simply that some part is so locally conditioned as to outlast its fellows.

25. To account for the phenomenon, analogy tempts us to jump to the conclusion that elevation is responsible for the survivorship. And so it has been thought to be by many who have philosophized on the subject. For this would be the fact on earth, and the same we are, therefore, prone to impute to Mars. But consideration shows that such cannot be the case.

Cold increases with ascent above sea-level because the enveloping blanket of air or rather of water vapor thins out as we rise. On the earth in latitude 45° an elevation of a couple of miles is usually enough to bring one into the region of perpetual snow. But on Mars this would not be the case. On Mars the cold could not increase thus with the speed it does on earth. It is possible to affirm this without any regard to the actual amount of atmosphere upon that planet. For it is a simple matter of physics with which we have to do.

26. The mere mass of a planet decides the distribution of its atmospheric envelope. It does this irrespective of what the amount of that envelope may be. No matter how dense or how rare the air be at the planet's surface, the air diminishes upward by a law which depends directly and primarily upon the planet's mass. This law is found as follows:

Since the density of the air varies primarily as the pressure put upon it, we have at the point, if D denotes the density, p the pressure and g the force of gravity

$$\frac{dp}{dx} = c\frac{dD}{dx} = -ap = agD$$

whence

$$\frac{dD}{D} = agdx$$

The minus sign denotes that x diminishes as D increases. If we assume $a = 1$ we have

$$\frac{dD}{D} = -gdx$$

whence

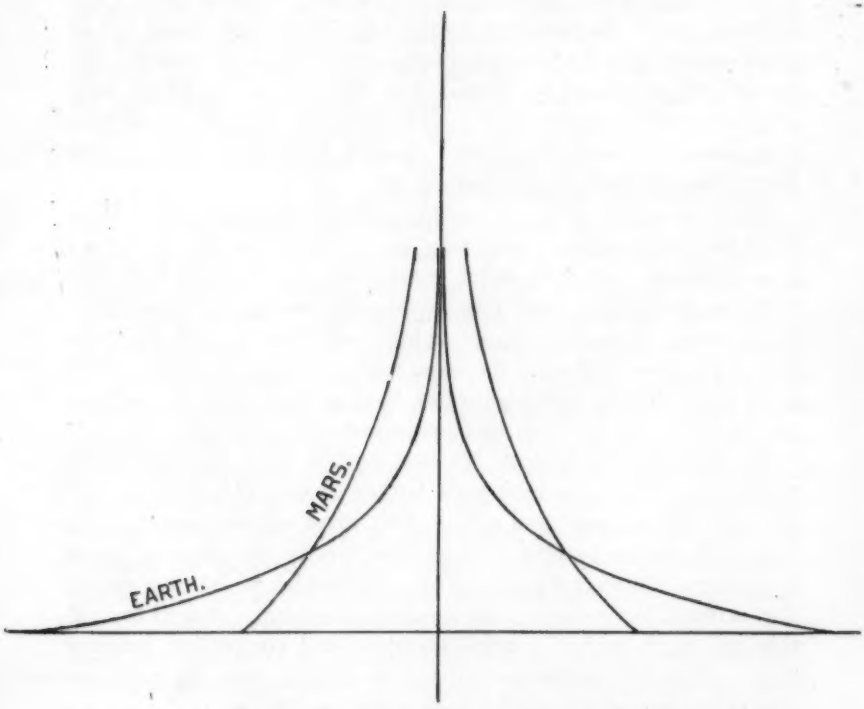
$$\int \frac{dD}{D} = log\ D = -gx$$

or

$$D = e^{-gx}$$

For another planet we have in the same way

$$D = e^{-gx}$$



Curves showing variation in density of atmospheres on the Earth and on Mars.

Thus the height necessary to bring about the same relative amount of density upon two planets varies inversely as their respective surface gravity.

(I do not here consider temperature, which, according to some researches of my friend, Prof. Story, may possibly set superior limits to all planatory atmospheres.)

27. In consequence of this to compass a result for which a moderate ascent would suffice on earth, an immoderate one must be made on Mars. For gravity there being but 2⅔ our own, nearly three times the rise is necessary. A Mt. Everest would stand for an Etna and something no less than eight miles high for a Mt. St. Elias. If such peaks existed, they could not fail of detection. Nevertheless none have been made out, nor are there any certain signs of even much lesser elevations. What have been most supposed to suggest them—the projections which, illuminated by slant lightning across the sunset or sunrise edge of the disk, stand out as bright points upon the terminator—do not tally with the look of hills, but are best explained by cloud. For they change in aspect only as clouds could contrive to do. Nor are other indications of possible mountains more expressive. Indeed, from every point of view Mars presents itself to us as futilely flat.

28. Dispensing, then, with earthly analogies we must look to Mars itself for explanation. Surveying the surface with this intent we presently note one trait which marks off the southern from the northern hemisphere—the relative absence in the latter of blue-green areas. It is, indeed, not a little odd how devoid the one-half of its globe is of what the other makes so fair a showing. The great mass of dark markings are to be found on that part of the planet which lies between the equator and the south pole.

29. Pursuing the subject, we find further that the blue-green regions are widest, reaching both farther down and higher up, between longitudes 300° and 90°. Here these regions stretch away to or fade into the arctic circle. Now it is in the centre of these longitudes, half way, roughly, across the breadth of the blue-green, that is found the centre of the southern snow-cap. Bowed toward this region, it evidently acknowledges some compelling potency there. And the continuance of the obeisance from the cap's beginning to its end points to a cause itself continuous.

30. The blue-green areas are, without doubt (see 23), vast vegetation bottoms. Though the dip is unquestionably but slight, it suffices to drain into them sub-ærially or surface-wise such moisture as may be present in the neighborhood. Whence their clothing of grass or forest or what does for these in Martian flora, their

like-tinted summer habiliment of green. Bottom-lands, not elevations then, are the cause of the snow's survival.

We are next concerned, therefore, with the way in which they may bring such result about. Just as it is not height but depth that determines the deposition, so it does this in quite unlike a manner. For by its indirect effects, more than by its direct efficiency, does it prove potent. Moisture in the air, it is true, flows into these lower levels because they are such, being hollows in the atmospheric ocean-bed. And they are such for water vapor over and above what they are for air, inasmuch as water vapor, though the lighter gas, is found most copious near the surface, thinning out more rapidly than the rest of the air upward. Depression is not so slight a factor as we proved elevation to be, because of this greater thinning out of moisture upward. But, even so, difference of level does directly but a part of the business. Indirectly depressions do something more: they start vegetation. Vegetation itself then takes a hand in the matter. Due to the humidity originally, once on the ground it reinforces the latter's action. For as a part of its life economy the plant is busied in pumping up water from the earth for the sake of the substances held there in solution which it absorbs, and setting the residue free allows it to evaporate away. Thus the moisture attracted to the spot is returned to the air about it, to be again deposited on provocation.

The deposit would not probably take the shape it does on earth. So thin, undoubtedly, is the air upon the surface of Mars that a precipitation in the form of rain or snow would seem not so likely a method of deposit as that other form dependent on contact which we know as dew or hoar-frost. In which case the deposit would occur nearer the place of generation, since it would offer less chance to be wafted to the winds. Being in a valley, the wind would get less sweep, and plant growth would still more hinder and hamper its course; and, secondly, what moisture was caught up and snatched away would be unlikely to be precipitated elsewhere. It would eventually return, to begin its plant work once more. Somewhere not far to the northward, then, of the general reservoirs of humidity, the great blue-green regions, we should expect to find the greatest accumulation of hoar-frost. This is precisely where we observe the centre of the snow-cap.

31. That the little midsummer remnant of the south polar cap lies at some distance from the pole, proves its survival due not to

the fortune of its position, but to its own self-preserving thickness. Of the northern snows, on the other hand, what is left over from year to year owes its conservation solely to latitude. Thus the survival of the little snow that is left at the southern pole, instead of proving the potency of the eccentricity, actually accentuates its impotence. Were it not for the presence of the lowlands with the increased moisture they gather and bequeath, there would be no eternal snow around the southern pole at all.

32. Thus this second characteristic of the polar patches, the centring of the one, the eccentring of the other, corroborates and enforces the testimony borne by the maxima and minima. For it shows that the minima are in truth more accentuated than they appear to be. The little minimum at the south pole would vanish entirely every year, instead of sporadically, were it not for local causes.

33. Our survey of the Martian polar caps, then, leads us to some curious conclusions. It starts with apparent contradiction of Croll's theory, to end in final confirmation of it. It comes to curse and stays to bless. But it does more. It shows that eccentricity of orbit by itself not only causes no universal glaciation, but actually produces on occasion the opposite result in more than offsetting by summer proximity what winter distance brings about. Eccentricity needs water and a great store of it as handmaid before its glacial work can be accomplished. Could our earth but get rid of its oceans, we, too, might have temperate regions stretching to the poles.

Stated Meeting, December 7, 1900.

Vice-President WISTAR in the Chair.

Present, 13 members.

A communication was made by R. W. Shufeldt, M.D., "On the Osteology of the Striges."

The following annual reports were read:

The Treasurer.

The Curators.

The Publication Committee.

The Hall Committee.

The Library Committee.

The Phillips Prize Essay Committee.

The Librarian laid upon the table the list of donations to the Library, and thanks were ordered therefor.

The Society was then adjourned by the presiding officer.

ON THE OSTEOLOGY OF THE STRIGES.

[STRIGIDÆ AND BUBONIDÆ.]

(Plates X-XVII.)

BY R. W. SHUFELDT, M.D.

(*Read December 7, 1900.*)

INTRODUCTION.

Of all my published scientific papers, or in fact of any of my writings, the first to appear was a memoir devoted to the *Osteology of Speotyto cunicularia hypogæa* (Bull. U. S. Geol. and Geogr. Surv. of the Terr., Dept. of the Interior. Vol. vi, No. 1. Washington, 1881). This contribution to the anatomy of the Burrowing Owl was quite complete, and illustrated by many figures given principally upon three full-page lithographic plates. It was done, however, far from all civilization, the museums and the libraries, and therefore offered but few comparisons in its pages with the osteology of other species of Owls.

This paper underwent a partial revision at my hands and appeared again in my work entitled *Contributions to the Anatomy of Birds* (12th Ann. Rep. of the late U. S. Geol. and Geogr. Surv. of the Terr. [Hayden's]. Washington: Govt. Printing Office, Oct., 1882. Author's Edition). Some little improvement was made in the paper, but the same plates and figures were reproduced, and no general comparisons included in the research. In the present memoir a large number of osteological comparisons have been made, substantially based upon the facts brought out in the original and revised issues of the *Speotyto* article, and the characters found upon examination to present themselves in the skeletons of other American *Strigidæ*, specimens of which at this time are not lacking

in either my private collection or in the collections of the U. S. National Museum at Washington. All the figures, however, illustrating the early papers on the osteology of the Burrowing Owl have in the present memoir been omitted, it not having been thought necessary to republish them, as they can be consulted by any student of the subject in the above quoted publications. This does not, however, apply to the text matter of the original article, for it is taken up in the present work and incorporated in the general comparisons made throughout, wherein the osteological characters of all the American species of Owls have been contrasted and employed to meet the ends of taxonomy. Apart from a few brief notes, the anatomy of Owls was not touched by me again until 1889, when in the *Journal of Morphology* (Vol. iii, No. 1. pp. 115–125, Pl. vii) I contributed a paper on the Burrowing Owl, entitled *Notes on the Anatomy of the Speotyto cunicularia hypogæa;* but little was said in it about the osteology of the species.

Several years later I published in one place or another a number of papers treating of fossil birds, and in some of these descriptions of fossil bones of Owls are given, notably of a *Bubo* in my memoir on *A Study of the Fossil Avifauna of the Equus Beds of the Oregon Desert* (*Jour. Acad. Nat. Sci. Phila.*, Vol. ix, Pls. xv–xvii, 4to, Phila., Oct., 1892, pp. 389–425). Quite a number of popular papers were also published about the American species of the *Strigidæ*, but nothing of a nature to be considered here. Indeed, up to the present writing I have published no paper requiring further notice in this place, beyond my memoir entitled *Professor Collett on the Morphology of the Cranium and the Auricular Openings in the North-European Species of the Family Strigidæ* (*Jour. Morphology*, Vol. xvii, No. 1, Boston, 1900). This somewhat elaborate production, upward of one hundred printed pages, is illustrated by thirty lithographic figures of the skulls and plucked heads of Owls, and some seven or eight text figures of a similar character. A number of genera and species are thus shown, but none of those figures are reproduced here, for the same reason as the one given in a former paragraph of this Introduction.

The present memoir, however, claims to be a very general contribution to the study and comparison of the osteological characters presented on the part of the skeletons of all the North American species, or at least genera, of *Strigidæ*. The most of the text figures here offered have never been published by me heretofore, and the

same applies to the thirty figures given on the Plates. In fact, in the case of the latter no one of them has ever been given before in any memoir anywhere. For the first time now we have here the relations of the cranial segments at the base of the skull in the nestling *Bubo;* the internal view of the skull in the adult; the cranium of *Megascops* and skeleton of *Micropallas* figured, and a good many other specimens of the bones of Owls which have never been published before. It is believed that these will be found to be useful not only to the comparative osteologist, but to the researcher in the fields of avian palæontology. Further, it will be found that in the present memoir descriptions have been given and intercomparisons made of the osteological characters presented on the part of many of the species of the genera of *Strix*, *Asio*, *Surnium*, *Scotiapex*, *Nyctala*, *Megascops*, *Bubo*, *Nyctea*, *Surnia*, *Speotyto*, *Glaucidium* and *Micropallas*, the whole being completed with a brief discussion of the probable affinities of the *Strigidæ* and their place as a group in the system.

WASHINGTON, D.C., November 21, 1900. R. W. S.

Owls of a number of genera, represented by a variety of species, are to be found in the avifauna of the United States. That North American alucoline type of the Barn Owls, *Strix pratincola*, ranges throughout the southern and warmer parts of the country. The genus *Asio* is represented by two species, *Syrnium* by two and a subspecies, while far north *Scotiapex cinerea* and *Scotiapex c. lapponica* are occasionally found. Of the smaller Owls, *Nyctala* is represented by one species and a subspecies, the best known one being *N. acadica*, now becoming quite rare. Screech Owls of the genus *Megascops* are especially numerous and of wide geographical range, ornithologists having recognized at the present time two species of them and at least half a dozen subspecies, but some of the latter require an eye highly educated in the matter of the fine discrimination of shades of color to distinguish them.

Great Horned Owls of the genus *Bubo* have the well-known *Bubo virginianus*, of which there seem to be at least three fairly well-marked geographical races or subspecies—a Western one (*subarcticus*), one in the Fur Countries (*arcticus*), and a Northwest Coast region variety, which has also been taken in Labrador (*saturatus*). We also have the magnificent Snowy Owl (*Nyctea nyctea*), as well as two Hawk Owls (*Surnia*), and those other Owls, known as

"Burrowing Owls," of the genus *Speotyto*, of which there are two varieties. Finally, in the Western and Southwestern regions we meet with the highly interesting little Pygmy and Elf Owls—two of the genus *Glaucidium* and the still more diminutive Elf, *Micropallas whitneyi*.

The Striges constitute a very cosmopolitan group of birds, and a wonderfully monomorphic one, there being hardly an aberrant form in the entire suborder the world over. But even at the present writing the classification of these birds is in a condition anything but satisfactory, and in times not long gone by the nomenclature of Owls was something quite past comprehension and utterly confusing.

Presently I shall quote some authorities in these matters when I come to say a few words upon the Owls in general, but right here, be it said, that beyond that the present memoir will have but little to do with the unraveling of this perplexing taxonomy and nomenclature. For the purpose of designating species and genera, I here adopt the arrangement set forth in the Check List of the American Ornithologists' Union—the last edition. Huxley, in his celebrated paper, published in the *Proceedings* of the Zoölogical Society of London in 1867, says that his Actomorphæ is a division which is equivalent

"to the 'Raptores' of Cuvier—an eminently natural assemblage, and yet one the members of which, as the preceding enumeration of their character shows, vary in most important particulars.

"They appear to me to fall naturally into four well-defined primary groups—the *Strigidæ*, the *Cathartidæ*, the *Gypætidæ* and the *Gypogeranidæ*. But this arrangement is so different from that ordinarily adopted, that I shall proceed to justify it by enumerating the principal circumstances in which the members of the several divisions agree with one another and differ from the rest."

This is first followed by a fairly complete *résumé* of the osteological and other characters of the Owls, but as many important skeletal characters have, since that paper was published, been described by ornithotomists, we will omit here Prof. Huxley's synopsis in these matters, and present the fuller and more recent remarks of Prof. Newton and others in the premises.

In his admirable article "Ornithology" in the Ninth Edition of the *Encyclopædia Britannica* (v. xviii, p. 47), Prof. Newton says that "It has so long been the custom to place the Owls next to the diurnal Birds-of-Prey that any attempt to remove them from that position cannot

fail to incur criticism. Yet when we disregard their carnivorous habits and certain modifications which may possibly be thereby induced, we find almost nothing of value to indicate relationship between them. That the *Striges* stand quite independently of the *Accipitres* as above limited can hardly be doubted, and, while the *Psittaci* or Parrots would on some grounds appear to be the nearest allies of the *Accipitres*, the nearest relations of the Owls must be looked for in the multifarious group *Picariæ*. Here we have the singular *Steatornis*, which, long confounded with the *Caprimulgidæ*, has at last been recognized as an independent form, and one cannot but think that it has branched off from a common ancestor with the Owls."

And the same excellent authority in the volume just quoted, under the article "Owl" further says, on page 89, that

"The Owls form a very natural assemblage, and one about the limits of which no doubt has for a long time existed. Placed by nearly all systematists for many years as a Family of the Order *Accipitres* (or whatever may have been the equivalent term used by the particular taxonomers), there has been of late a disposition to regard them as forming a group of higher rank. On many accounts it is plain that they differ from the ordinary diurnal Birds-of-Prey, more than the latter do among themselves; and, though in some respects Owls have a superficial likeness to the *Goatsuckers*, and a resemblance more deeply seated to the *Guacharo*, even the last has not been made out to have any strong affinity to them.[1]

"A good deal is therefore to be said for the opinion which would regard the Owls as forming an independent Order, or at any rate Suborder, *Striges*. Whatever be the position assigned to the group, its subdivision has always been a fruitful matter of discussion, owing to the great resemblance obtaining among all its members, and the existence of safe characters for its division has only lately been at all generally recognized.

"By the older naturalists, it is true, Owls were divided, as was first done by Willughby, into two sections—one in which all the species exhibit tufts of feathers on the head, the so-called 'ears' or 'horns,' and the second in which the head is not tufted. The artificial and therefore untrustworthy nature of this distinction was shown by Isidore Geoffrey St. Hilaire (*Ann. Sc. Naturelles*, xxi, pp. 194–203) in 1830; but he did not do much good in the arrangement of the Owls which he then proposed; and it was hardly until the publication ten years later of Nitzsch's *Pterylographie* that rational grounds on which to base a divis-

[1] This last remark rather borders upon inconsistency when strictly taken with what this writer has said in his article "Ornithology" quoted in a former paragraph above.

ion of the Owls were adduced. It then became manifest that two very distinct types of pterylosis existed in the group, and further it appeared that certain differences, already partly shown by Berthold (*Beitr. zur Anatomie*, pp. 166, 167), of sternal structure coincided with the pterytological distinctions. By degrees other significant differences were pointed out, till, as summed up by Prof. Alphonse Milne-Edwards (*Ois. foss. de la France*, ii, pp. 474–492), there could no longer be any doubt that the bird known in England as the Screech Owl or Barn Owl, with its allies, formed a section which should be most justifiably separated from all the others of the group then known.

"Space is here wanting to state particularly the pterytological distinctions which will be found described at length in Nitzsch's classical work (*English Translation*, pp. 70, 71), and even the chief osteological distinctions must be only briefly mentioned. These consist in the Screech Owl section wanting any manubrial process in front of the sternum, which has its broad keel joined to the clavicles united as a furcula, while posteriorly it presents an unbroken outline.

"In the other section, of which the bird known in England as the Tawny or Brown Owl is the type, there is a manubrial process; the furcula, far from being joined to the keel of the sternum, often consists but of two stylets which do not even meet one another; and the posterior margin of the sternum presents two pairs of projections, one pair on each side, with corresponding fissures between them. Furthermore, the Owls of the same section show another peculiarity in the bone usually called the tarsus. This is a bony ring or loop bridging the channel in which lies the common extensor tendon of the toes—which does not appear in the Screech Owl section any more than in the majority of birds. The subsequent examination by M. Milne-Edwards (*Nouv. Arch. du Muséum*, ser. 2, i, pp. 185–200) of the skeleton of an Owl known as *Phodilus* (more correctly *Photodilus*) *badius*, hitherto attached to the Screech Owl section, shows that, though in most of its osteological characters it must be referred to the Tawny Owl section, in several of the particulars mentioned above it resembles the Screech Owls, and therefore we are bound to deem it a connecting link between them. The pterytological characters of *Photodilus* seem not to have been investigated, but it is found to want the singular bony tarsal loop as well as the manubrial process, while its clavicles are not united into a furcula and do not meet the keel, and the posterior margin of the sternum has processes and fissures like those of the Tawny Owl section. *Photodilus* having thus to be removed from the Screech Owl section, Prof. Milne-Edwards has been able to replace it by a new form *Heliodilus* from Madagascar, described at length by him in M. Grandidier's great work on the natural history of that island (*Oiseaux*, i, pp. 113–118). The unexpected results thus obtained preach caution in regard to

the classification of other Owls, and add to the misgivings that every honest ornithologist must feel as to former attempts to methodize the whole group—misgivings that had already arisen from the great diversity of opinion displayed by previous classifiers, no two of whom seem able to agree.

"Moreover, the difficulties which beset the study of the Owls are not limited to their respective relations, but extend to their scientific terminology, which has long been in a state so bewildering that nothing but the strictest adherence to the very letter of the laws of nomenclature, which are approved in principle by all but an insignificant number of naturalists, can clear up the confusion into which the matter has been thrown by heedless or ignorant writers—some of those who are in general most careful to avoid error being not wholly free from blame in this respect."

Did my space but admit of it, I would here republish even still more of this admirable article of Prof. Newton's, as in my opinion it constitutes one of the most able short contributions that has ever been added to the literature of this subject.

Upon consulting the Plates and text of so distinguished an authority's work as Prof. Max Fürbringer's *Untersuchungen zur Morphologie und Systematik der Vögel*, we are to note that there the *Caprimulgi* and *Striges* are considered as arising from a common ancestral stock, the suborder *Coraciiformes* of the Order *Coracornithes*, and this last-named division is quite apart from the Order *Pelargonithes*, which contains the *Accipitres*. This is the view which is held by the present writer, and in so far as our United States Owls are concerned I consider the suborder *Striges* is represented by the two families—(1) the *Strigidæ*, containing the single genus and species, *Strix pratincola*, and (2) the *Bubonidæ*, which holds all the others—some eleven genera with the many species enumerated above.

Mr. F. E. Beddard, in a very excellent little paper published not long ago in *The Ibis*, says upon this point that

"the most obvious characters which distinguish the skull of *Strix* from that of the remaining genera have been pointed out by Milne-Edwards;[1] they are, firstly, the greatly elongated and narrow form of the skull in *Strix* contrasted with the wide short skull of other types; secondly, the relatively great thickness of the bones which make up the interorbital septum in *Strix* as compared with the extremely thin interorbital septum of other Owls.

[1] *Nouv. Arch.*, etc., p. 189.

"I find by a series of measurements of the skulls of the following types—

Strix flammea	*Bubo bengalensis*
Strix sp?	*Syrnium indrani*
Asio mexicanus	*Syrnium woodfordi*
Speotyto cunicularia	*Ketupa javanica*
Athene noctua	*Sceloglaux albifacies*
Bubo maximus	*Nyctea nivea*

that while *Strix* has the narrowest skull (the proportion of the greatest breadth to length being in *Strix* sp. inc. as 37.5 : 62, in *Strix flammea* 36 : 56), the other genera show a progressive widening of the skull; this culminates in *Speotyto cunicularia*, where the breadth is to the length as 37 : 38. I do not give the exact measurements in the other species mentioned in the present list, for the reason that such a table of measurements would only be of value if it embraced the results of a study of a larger number of species and of individuals. I may state, however, that I have examined a large number of Owls' skulls in the British Museum Collection, including those of two other species of *Strix* (viz., *S. perlata* and *S. delicatula*), and in no case do I find so long and narrow a skull as in the genus *Strix*. It may be worth while mentioning that *Sceloglaux albifacies* has a skull which comes nearer to that of *Strix* in its relative proportions than do the skulls of many other genera. The reason which leads me to lay some stress upon this fact is the opinion of Prof. Newton [1] that this curious Owl may prove to be intermediate between the *Strigidæ* and other Owls. I hope, however, to be able, at some future time, to compare the skeleton of *Sceloglaux* with that of *Strix*.

"Prof. Milne-Edwards, in his memoir upon *Photodilus*, shows plainly that this genus belongs to the Bubonine and not to the Strigine group in the proportions of the skull and in the possession of a flattened interorbital septum.

"There is one feature in the skull of the Striges, serving to distinguish the *Strigidæ* from the *Bubonidæ*, which has apparently escaped the attention of Prof. Milne-Edwards. In *Strix*[2] the prefontal processes of the ethmoid are rounded and much swollen. In *Bubo* and in all other genera of Owls which I have had the opportunity of studying the same processes are thin, leaf-like expansions, as they are in the *Accipitres diurnæ*. With regard to the other points of difference in the skull, I must refer the reader to Prof. Milne-Edwards' memoir." . . . .

[1] *Encycl. Brit.*, art. "Owl."

[2] Mr. Beddard gives very excellent figures in this paper of the basal views of the skulls of *Strix flammea* and *Bubo bengalensis*, but I have not reproduced these, and the reader can find the points referred to in other figures illustrating the present memoir and two views of the skull of *Strix* in the Plates.

Of the bones of the foot, Mr. Beddard also says that

"a comparison of the relative length of the phalanges of the third digit appears to afford another character for the discrimination of the *Striginæ* and *Buboninæ*.

"In *Strix* (Fig. 1) the first phalanx of that digit is markedly shorter than the second phalanx. In *Bubo* (Fig. 2) and in the other genera the two phalanges in question are subequal." . . . .

According to Beddard, in the paper we have been quoting,

"the principal osteological characters of the genus *Strix*, and which apparently distinguish it from all others, are the following:

(1) The skull is relatively long and narrow.

(2) The palatines are straight, nearly parallel to each other; they are of approximately the same width throughout; they almost conceal the underlying maxillo-palatines, which are broader from above downward than from side to side.

(3) The prefrontal processes of the ethmoid are rounded bones of some width.

(4) The interorbital region of the skull does not form a thin plate anteriorly, but is of considerable width from side to side.

(5) The sternum has but one notch on either side.

(6) In the foot the second joint of the third toe is considerably longer than the basal joint.

(7) There is no bony ridge upon the tarso-metatarsus.

"On the other hand, in the Bubonidæ the skeleton has the following characters:

(1) The skull is relatively broad and short.

(2) The palatines are curved, the hinder part of the bone being much wider than the anterior region; the maxillo-palatines are very broad from side to side.

(3) The prefrontal process of the ethmoid is a thin plate.[1]

(4) The interorbital plate is thin and often fenestrated.

(5) The sternum has two notches on either side.

(6) In the foot the second joint of the third digit is subequal in size to the basal joint.

(7) There is a bony ridge upon the under surface of the upper end of the tarso-metatarsus."

---

[1] In *Athene noctua* and *Speotyto cunicularia* these processes are very small and are hidden by the palatines when the skull is viewed from the ventral surface. The skull is broader in these two genera than in any others examined by me, and the maxillo-palatines are smaller.

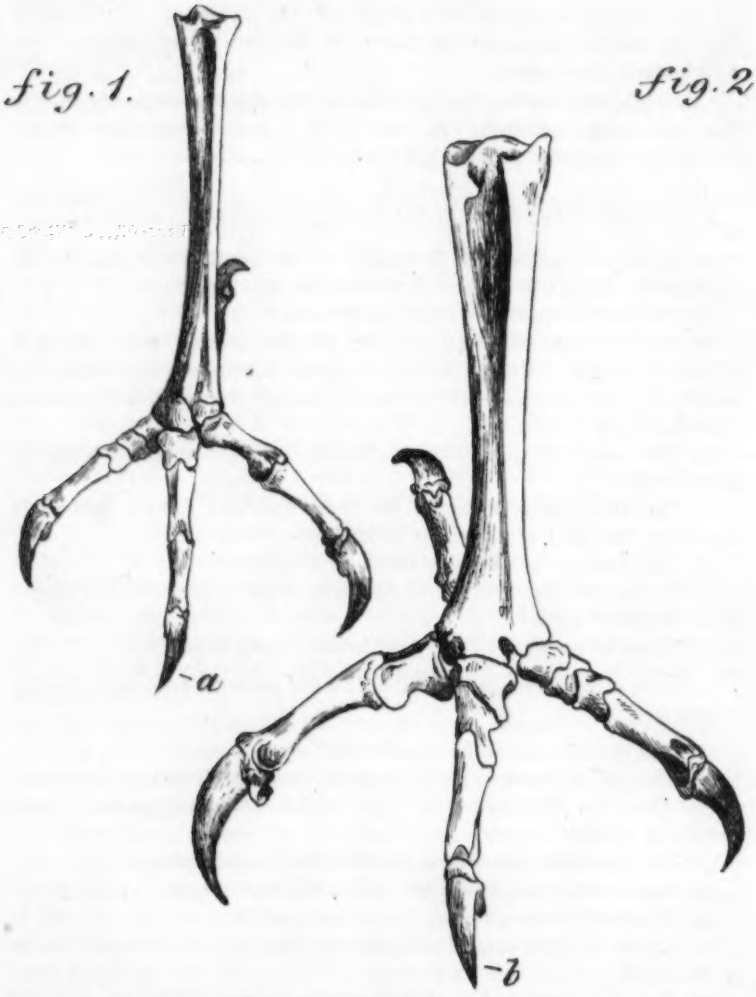


Fig. 1. Right foot of *Strix flammea* (nat. size). Fig. 2. Left foot of *Bubo bengalensis* (nat. size).

Both figures are sketches by the author from Beddard's figures, and the one of *B. bengalensis* will answer very well for any representative of that genus, as *B. virginianus*. *a* and *b* direct attention to the third digit where the subequality of the basal phalanges is seen.

Mr. Beddard found these differences supported in the two Strigine families in question by the dissimilarities that were exhibited on the part of the tensores patagii and the syringes. He presents very good figures of these last-mentioned structures as they occur in *Strix flammea*, *Bubo maculosus* and *Scops leucotis*.

Upon examining a skeleton (No. 18196) of our own American Barn Owl (*Strix pratincola*) in the collections of the United States National Museum, as well as the trunk skeleton of one in my private cabinets, I find that there are a number of good characters, referable to the osseous system of this bird, which are not noted by Mr. Beddard in the list of characters I have quoted from him above (see Pl. XIV, Fig. 21, and Pl. XV, Figs. 24 and 25). And as these characters are quite distinctive when we come to compare the skeleton of this Owl with a skeleton of any of the typical *Bubonidæ*, I will enumerate them here:

(1) The vomer is notably large in *Strix pratincola*.

(2) And in it, comparatively, the lacrymal is a very large bone and has considerable antero-posterior length.

(3) The manubrium on the sternum is aborted.

(4) The mid-lower point of the os furcula makes a pseudo-articulation with the anterior carinal angle of the sternum. It has been said that in very old Owls of this species anchylosis may take place at this point.

(5) The antero-lateral angles of the ilia are produced forward as prominent processes.

(6) An os prominens is not developed at the distal end of the radius.

(7) The head or proximal end of the tarso-metatarsus is twice perforated in the antero-posterior direction.

(8) Two vacuities are seen in the expanded portion of the proximal phalanx of the index digit.

This last-mentioned character reminds one of what we likewise find in some of the American *Caprimulgi*.

Agreeing with other Owls, we find in *Strix pratincola* nineteen free vertebræ between skull and pelvis, and eight in the skeleton of the tail, which count includes the pygostyle.

In the arrangement of the ribs we find them to vary; a specimen of *Stix pratincola* before me has a tiny pair of free ribs on the thirteenth vertebræ; they are larger on the fourteenth; while on the fifteenth the rib does not join with the sternum on the left side, but

does so by a costal rib on the right. None of the ribs thus far mentioned bear epipleural appendages. Now, in a specimen of *Asio wilsonianus*, the first pair of tiny free ribs occur upon the twelfth cervical vertebra; the next pair are considerably larger, while those on the fourteenth have epipleural appendages, and both connect with the sternum.

Strix pratincola also often has a pair of "floating ribs" behind the last dorsal pair. In this Owl, too, we find a very large patella. All Owls have a notably long fibula, while in *Strix* it is quite perfect and comes down very close to the condyle of the tibio-tarsus. The relative lengths of the bones of the lower extremity are rather remarkable in *Strix pratincola*. In a mounted skeleton (18196) in the cases of the United States National Museum of this species, I find the femur to measure 6.5 centimetres, the tibio-tarsus 11 centimetres, and the tarso-metatarsus 7.9 centimetres.

As is now well known, a variety of species of Owls have asymmetrical skulls, an asymmetry that is due largely to a distortion of the postfrontal and squamosal regions of the cranium. It may occur, I believe, upon either side. *Bubo virginianus*, however, presents us with no such character in its skull, and this Owl possesses a lofty superior osseous mandible, with the nasal septum completed in bone, all to a small space behind. In it, as in most Owls, the lower part of the great spongy lacrymal is moulded upon the still larger maxillo-palatine beneath; the last also being a tuberous, spongy mass, of a form something like a small chestnut, with the bulbous end to the rear. These maxillo-palatines do not meet each other mesially, and they rest, on either side, upon the horizontal prepalatine blade of the palatine bone (see Plate XII, Fig. 10).

In the lacrymal region a large foramen exists externally, the walls of which are formed chiefly by the lacrymal, the nasal and the maxillo-palatine. It passes into the rhinal chamber. As Mr. Beddard has already pointed out, the pars plana in all of the Bubonidine type of Owls is comparatively small and of a thin, plate-like structure. It is quite small in *Bubo virginianus*, and in all of the Owls wherein it exists, as we have just described it, it is so turned as to form a partial rest for the eye anteriorly, rather than an osseous partition between orbit and rhinal space beyond.

A very small vacuity may exist in the interorbital septum in *Bubo* and some strigine forms related to that genus, but it is of by no means a common occurrence.

All of the Owls I have ever examined possess basipterygoid processes, and I have often wondered what species of these birds Sir Richard Owen referred to when he wrote that they were absent in Owls (see *Anat. Verts.*, Vol. ii., p. 49).

On the superior aspect of the skull, such Owls as *Bubo* are narrow in the frontal region between the margins of the orbits, and the fronto-orbital processes are short and stumpy.

Another thing to be noticed in these large Owls is the prominent manner in which the frontal region of the skull overreaches the naso-premaxillary region in front of it. The frontal bones really bulge forward here, creating a very striking feature, totally absent in such a species as *Strix pratincola*, and only moderately well developed in some other Owls. The Owl's skull that shows it the best of all the specimens before me is one from *Bubo maximus*, a Japanese species, but it is by no means slightly marked in our own *Bubo virginianus* (see Fig. 4).

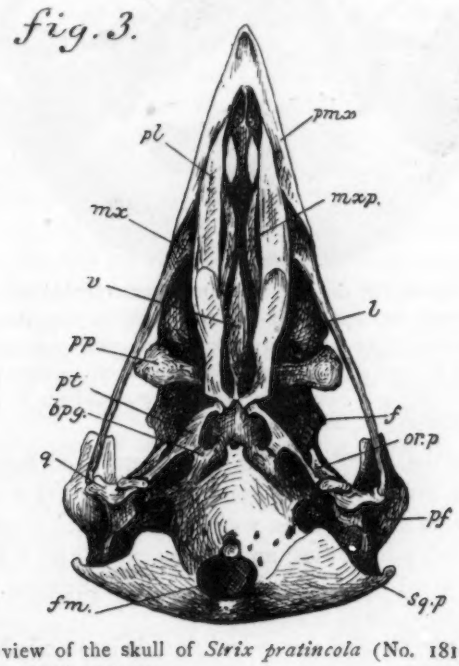


FIG. 3. Basal view of the skull of *Strix pratincola* (No. 18196, U. S. Nat. Museum). Adult; life-size.

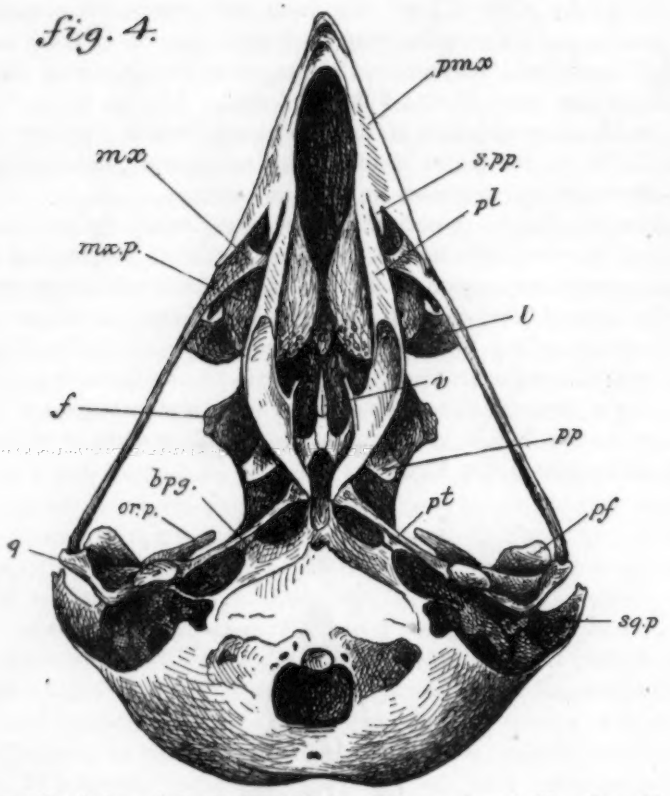


FIG. 4. Basal view of the skull of *Bubo maximus* (Japan) (No. 18227, U. S. Nat. Museum). *pmx.*, premaxillary; *mx.*, maxillary; *pl.*, palatine; *mx. p.*, maxillo-palatine; *s. pp.*, secondary palatine process; *l.*, lacrymal; *f.*, frontal; *v.*, vomer; *p. p.* pars plana; *pt.*, pterygoid; *b.pg.*, basipterygoid process; *pf.*, post-frontal; *sq.p.*, squamosal process; *q.*, quadate; *or.p.*, orbital process of quadrate; *fm.*, foramen magnum.

Turning to the mandible of this last-mentioned species, we find it to be of a broad V-shaped pattern, with rather a shallow symphysis; truncate angular ends, with large inturned processes there; moderately high ramal sides, and always exhibiting a long, irregularly-shaped ramal vacuity near the middle of the same. This ramal vacuity is small in *Strix pratincola*.

Passing to the trunk skeleton and the skeleton of the limbs, we have but little to add to what has already been pointed out in the foregoing paragraphs of this memoir. With respect to the pelvis,

it calls to one's mind the skeleton of many of the diurnal Raptores, more than any other single part in the osseous framework of the Owls is wont to do. Some of the *Accipitres*, however, possess interrupted post-pubic elements; I have never observed this to be the case in any American Owl. But aside from this character, the general facies of the pelvis, say of such a species as *Syrnium nebulosum*, or many others, reminds us very much indeed of the pelvis in certain species of Hawks.

This does not as a rule apply especially to the sternum, nor yet to the shoulder-girdle. As we have already shown, the sternum in all of the *Bubonidæ* is strongly two-notched upon either side behind.

The outside pair of notches are usually very deep in representatives of the genus *Syrnium*.

Returning to *Bubo virginianus*, we see that in the skeleton of the arm the humerus is the only pneumatic bone, and the long slender radius is interesting from the fact that it has the os prominens articulated with its distal extremity, and a peculiar little osseous arch is found upon the side of its shaft at the proximal third of its continuity (see Fig. 5, *os. p.* and *oa.*).

The ulna is about three times the calibre of the radius, with the distal moiety of its shaft nearly straight, while the proximal half is gently arched. Bones of manus are all well-developed, but withal present us with no very striking characters. The differences seen in the expanded part of the proximal phalanx of index digit, respecting *Strix* and *Bubo*, have already been pointed out above.

In the *pelvic limb* we find all the bones nonpneumatic, and the points of interest to be the great length of the fibula and the peculiar form assumed by the tarso-metatarsus.

The characters of the joints of the toes have already been commented upon above. With respect to the tarso-metatarsus, we again meet with a bone that agrees in some of its features with the corresponding part of the skeleton among some of the *Accipitres*. The hypotarsus is single, prominent and placed to the inner side of the shaft. Deeply and longitudinally excavated adown the entire posterior aspect of its shaft, it is only partially so in front, and that for the proximal half of the bone. A bony bridgelet spans the latter excavation just below the head of the bone and to its inner aspect. This is also seen in *Pandion* among the diurnal *Raptores*; and in that form, too, we note a very perfect fibula—that is, for an ornithic type. Some other Hawks are not backward in that particular.

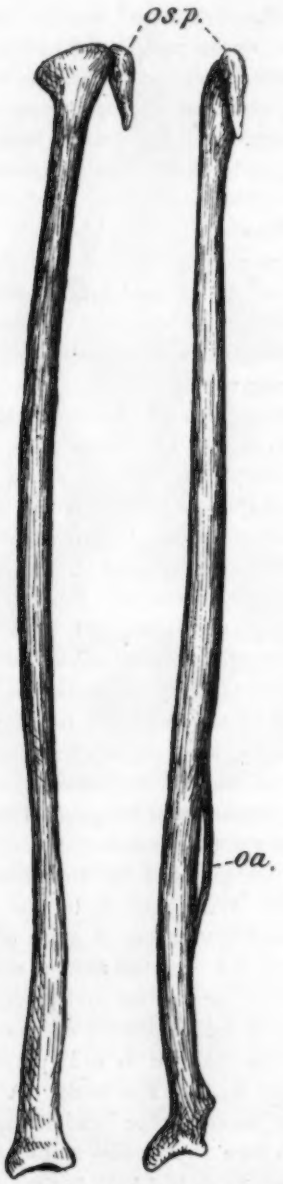


FIG. 5. Radius of an adult specimen of *Bubo virginianus;* drawn life-size. The bone on the left-hand side is seen upon superior aspect; the one on the right, upon anconal view. *os. p.*, os prominens; *oa.*, osseous arch.

The femur in *Strix pratincola* appears to be pneumatic. All Owls appear to be supplied with a large patella at the knee.

I shall now proceed to give a few selected extracts from my memoir on *Speotyto cunicularia hypogæa*, as I said I would do in the Introduction to the present memoir. A superficial examination of a skeleton of *Speotyto* is quite sufficient to convince us that its affinities are with the bubonine Owls rather than with the genus *Strix*. We will not then have to especially dwell upon this point.

Essentially, the characters of the skull and mandible of *Speotyto* are briefly as follows:

Owing to its delicate structure, it is a skull of extreme lightness; and as to form, its greatest width lacks but little of its being equal to its median longitudinal diameter. Vertically it is of moderate height, while the cranial vault externally is markedly smooth and rounded in the parietal and adjacent regions. The septum marium is complete, the external osseous nostrils being somewhat rounded ellipses in outline. Either lacrymal bone is free, and grooved upon its outer aspect for the lacrymal duct. Superiorly, we are to note in the frontal region that the skull is inclined to be narrow between the upper orbital margins; and the supraorbital processes, thrown outward and backward on either side by a frontal, are of spiculaform proportions. The thin interorbital plate or partition may, and usually does, show one small central vacuity in it. The nerve foramina are small and generally round in outline. Pars plana is meagrely developed, and presents the characters of the bubonine Owls generally. A quadrato-jugal bar is stout, and is peculiar in that upon its superior aspect, at the junction of middle and posterior thirds, it sends upward a transversely compressed triangular process, that also exists as a character in the skulls of *Surnia* and the Pygmy Owls among American species now at my hand. Postfrontal processes are broad and conspicuous, while a squamosal bone forms a great shell-like bulla that arches forward as a shield to the external auditory aperture. The antero-superior angle of this bulla, upon either side, fuses with the edge of the postfrontal at the orbital periphery, thus creating a small foramen there, which in the living bird transmits the tendon of the temporal muscle. The skull of *Speotyto* is symmetrical. Above the foramen magnum a well-marked supraoccipital eminence is seen, which is pierced mesially by a small and usually circular vacuity.

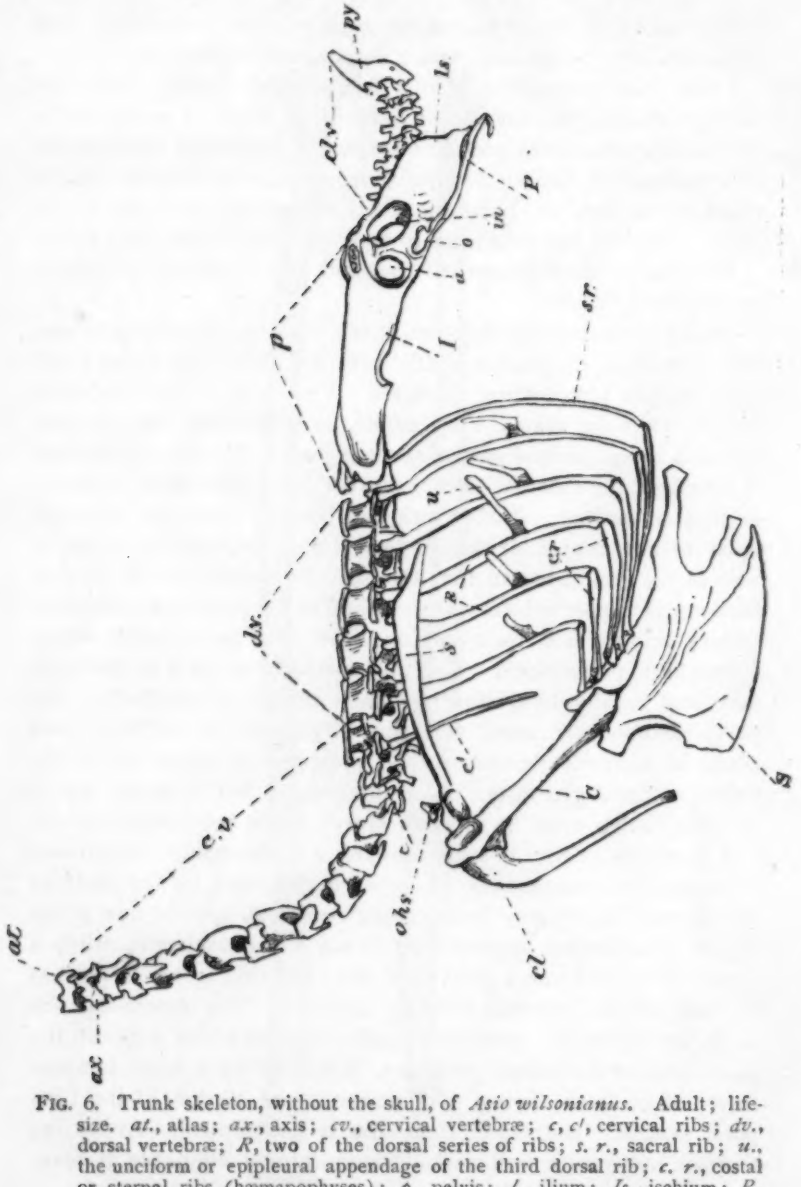


FIG. 6. Trunk skeleton, without the skull, of *Asio wilsonianus*. Adult; life-size. *at.*, atlas; *a.x.*, axis; *cv.*, cervical vertebræ; *c*, *c'*, cervical ribs; *dv.*, dorsal vertebræ; *R*, two of the dorsal series of ribs; *s. r.*, sacral rib; *u.*, the unciform or epipleural appendage of the third dorsal rib; *c. r.*, costal or sternal ribs (hæmapophyses); *p.*, pelvis; *I.*, ilium; *Is.*, ischium; *P.*, pubis; *a.*, acetabulum; *in.*, ischio-iliac foramen; *o.*, obdurator foramen; *clv.*, caudal vertebræ; *py.*, pygostyle; *s.*, scapula; *ohs.*, os humero-scapulare; *cl.*, clavicle; *C.*, coracoid; *S.*, sternum. (This figure is a lettered scheme to Fig. 30, Plate XVII.)

As in almost all Owls, the mastoidal part of the quadrate is notably long; and the well-developed basipterygoidal processes are present for articulation with the pterygoids. Palatines are not very wide, and they are inclined to be bowed outward along their lengths. Maxillo-palatines, too, are comparatively small and well separated from each other in the median line. They are of the same spongy structure that we see in the *Striges* generally. I am inclined to think that the vomer never ossifies in *Speotyto*, and, as we know, it is very small in a number of other Owls.

This little Burrowing Owl possesses a mandible of a form common to most of its family. A large ramal vacuity is always present in it upon either side, and the bone is pneumatic.

Speotyto has its orbits of comparatively large size, and the sclerotal plates of the eye itself are strong and ample.

The hyoid arches are suspended from the base of the skull by their usual attachments. In this Owl they consist of six separate little bones, involving five articulations. The tips of the upturned posterior extremities are about opposite the lower borders of the temporal fossæ, its two limbs diverging from each other at an angle equal to that made by the lower mandible. The ceratohyals are rather large in comparison with other bones. They are joined both anteriorly and posteriorly by bony bridges, forming a fenestra between them to be filled in by a thin membrane. The amount of divergence they make from each other is less than that made by the epibranchial elements of the thyrohyals. Anteriorly the bone connecting them supports a cartilaginous glossohyal, while the posterior connection presents for examination the usual smooth articulating surface that enters into the arthrodial joint it makes with the basibranchial. The first basibranchial and second basibranchial are confluent, not a sign of the point of union remaining. The latter bone is continued a short distance posteriorly by a tip of cartilage. The anterior end of the first basibranchial is devoted to the articular surface for the bone connecting the ceratohyals, forming the joint mentioned above. It is concave from above downward, convex from side to side, the lower lip being the longer. It will be plainly seen that this combination grants to the tongue a movement in the vertical and horizontal planes. The anterior articulating heads of the epibranchial elements of the thyrohyals are opposite each other, each being received into the diminutive acetabulum intended for it at the side of the united first and second

basibranchials, and most probably at the junction of the two latter bones. These two elements are long bones having a cylindrical shaft, terminating at either end in an articulating head. They are the longest bones in the hyoidean apparatus, and have a gentle curvature upward throughout their extent. The inner heads form an arthrodial joint on either side with the outer heads of the ceratobranchial elements of the thyrohyals. These, the last bones of the arch, are joined in the manner already shown above. Their inner ends are quite pointed, even as far as the bone goes, the extreme points being finished off with cartilage. They curve upward from about their middle thirds, and, like the first elements of the thyrohyals, they are long bones, but with curved cylindrical shafts, the outer end, however, being the only true articulating one.

The Spinal Column: Cervical Portion.—There are in *Speotyto* fourteen cervical vertebræ, each one having a more or less free movement with the one beyond and behind it, the chain maintaining in all positions some variation of the usual sigmoid curve observable in this division of the vertebral column throughout the class. The arrangement, as well as the direction, of the planes of the zygapophysial articular surfaces allow considerable rotary movement and bending in the vertical plane, with combinations of the two. It is a common habit of this bird, among other of his antics, to duck his head smartly downward and again upward, several times in succession, upon being approached. The calibre, as well as shape, of the neural canal in this portion of the spinal column varies at different points. It originates at the atlas as a transverse ellipse, with a major axis of four millimetres and a minor axis of a little less than three millimetres; this is about the maximum capacity throughout the entire canal. From the atlas to the sixth or seventh vertebra the ellipse gradually approaches the circle, with a marked diminution in size, its diameter being at the seventh about two millimetres in any direction. From this point to the twelfth, inclusive, it rises as it fell from the atlas, and in the same manner, when we again discover a transverse ellipse, perhaps a jot smaller than the one described in speaking of the atlas. In the thirteenth the canal is smaller than, though in all other respects it resembles, the twelfth; but an abrupt change takes place in shape as we pass to the fourteenth or last cervical, where the form of the neural tube suddenly approximates the circularity of the dorsal vertebræ. The vertebral canal begins, circular, on either side at the

third cervical vertebra, most of its length being immediately beneath the prezygapophyses of each segment. It is formed in the usual manner by the di- and parapophysial processes uniting laterally with the pleurapophysial elements. Small at the cephalic extremity of the column, its calibre gradually increases in each vertebra as we proceed toward the thoracic extremity, until it attains its maximum capacity at the eleventh vertebra. In the twelfth the integrity of its walls is lost by a parting of the par- and pleurapophysial elements, with a disappearance of the former, leaving it no floor, so that in this vertebra it ceases to be a closed canal. The most prominent object presenting itself for examination in the atlas, superiorly, is the deep reniform cavity for articulation with the occipital condyle of the basi-cranii. Below and posteriorly there is another articulating surface, convex for the centrum of the axis and concave for its odontoid process, accurately meeting the opposed surface of this vertebra and forming the atlo-axoid articulation. A lip of bone, a portion of the hypapophysis of the vertebra we are now describing, projects downward and shields this joint in front, overlapping indeed a good part of the axis. The neurapophyses of the atlas are slight in structure. The concave postzygapophyses articulate with the convex prezygapophyses of the axis. The bone is devoid of a neural spine. In the axis we find both an hypapophysis and neural spine developed, the former being produced from the ridge on the anterior aspect of the centrum of the bone. The odontoid process arises vertically from the posterior margin of the upper surface of the centrum. Its summit and anterior face are convex and articulating, while behind it is flat and continuous with the spinal canal. The facet for articulation with the centrum of the third vertebra looks downward and inward, is convex from side to side and concave in the opposite direction. The postzygapophyses are concave, look downward and outward, the conditions in the prezygapophyses being exactly the opposite; this is the rule throughout the cervical portion of the column. After we pass the atlas and axis, we find in the third cervical vertebra here, as in most vertebrates, parts that are common to the series of this portion of the column, deviating but slightly from each other as we examine them *in seriatim;* but gradually as this deviation proceeds some requisite condition is brought about when the climax is attained. The fact of the presence of a neural spine on the axis is

conveyed, though in a less marked degree, to the third or next vertebra below, where it occupies a position about the middle of the bone. As we pass toward the dorsal region this process becomes less and less prominent, being found set farther back on each successive vertebra; it disappears about entirely at the tenth, after which it rapidly begins to make its appearance again, assuming its former position in the middle of the vertebra, being quite evident in the twelfth in the shape of a pointed spine, while in the fourteenth it has the quadrate form, with extended crest, much as we see it in the true dorsal vertebræ.

In the third vertebra the space between the pre- and postzygapophyses is almost entirely filled in, a minute foramen on either side alone remaining, by a lamina of bone extending from one process to the other, giving to this vertebra a much more solid appearance, which in reality it possesses above that attained by any of its fellows. This bony lamina is reduced in the fourth vertebra to a mere "interzygapophysial bar" connecting the processes, while in the next succeeding one or two vertebræ it occurs only on the prezygapophyses more as a tubercle, being directed backward, then disappearing entirely, to be found again only on a few of the last cervicals as an ill-defined knob, still retaining its original position. The diapophyses at first project nearly at right angles from their respective centra, then approach the median line by being directed more backward near the centre of the cervical division of the column, and on nearing the dorsals again gradually protrude more and more directly outward. The prezygapophyses of the ninth cervical support well-marked anapophysial tubercles, which are feebly developed also on a vertebra or two above and below the ninth. The joints between the bodies of the cervicals of this Owl are upon the same plan as those found throughout the class; the anterior facet being concave from side to side, convex from above downward, the reverse being the case with the posterior facets, and when articulated fitting accurately into each other. The pleurapophysial elements, well marked in all the cervicals after passing the axis, become in the thirteenth vertebra a free cervical rib, about three millimetres in length, without neck or true head, being merely suspended on either side from the diapophyses of the vertebra, and freely movable on its exceedingly minute articulating facet.

Attached to the last cervical we find the second pair of free ribs, about two-thirds as long as the first pair of dorsals or true ribs of

the thorax. These terminate in pointed extremities and articulate with the vertebra by both capitula and tubercula, the former on elliptical facets, placed vertically on either side of the centrum at the anterior margin of the neural canal, and the latter on rounded facets beneath the transverse processes. The tubercle on one of these ribs is nearly as long as the neck; at the junction on the posterior side is found a pneumatic foramen of considerable size. These ribs are more or less flattened above from before backward, being convex anteriorly, concave posteriorly, becoming rounded below. From third to ninth vertebra, inclusive, appear beneath the vertical canal anteriorly well-developed styliform parapophysial processes, directed backward and downward. They are best marked on the segments on the middle of the neck. There is no instance in this bird of these processes being produced so far backward as to touch the next vertebra below; their tips, as a rule, about overhanging the middle of the centrum of the vertebra to which they belong. We have found in specimens of *Bubo virginianus* the parapophyses of the fourth vertebra overlapping and touching the fifth for a millimetre or more. The third and fourth cervicals have, beneath in the median line posteriorly, strongly developed hypapophyses, quadrate in form, a process that exhibits itself anteriorly on the fifth vertebra merely as a small tubercle. On the sixth this tubercle has disappeared, and has been supplanted by two others that are now found just within the periphery of the anterior facet of the centrum beneath, and on the parapophysis of each side, they being inclined toward each other. These processes, now a double hypapophyses developed from the parapophyses, continue to increase in size and inclination toward each other on the next three vertebræ, so that on the ninth, where they last appear, they nearly form a closed canal. The passage between them is intended for the carotids, to which they afford protection. The hypapophysis of the tenth, eleventh and twelfth vertebræ is single, large, quadrate and directed forward and downward. There are three on each of the last two vertebræ, each having an independent root, the two lateral ones directed downward, forward and outward, with characteristics similar to the one in the median line. Several pneumatic and nutrient foramina perforate each cervical vertebra at various points, except in the axis and atlas, where, after diligent search, aided by the lens, we have signally failed to discover them.

Dorsal Vertebræ; Vertebral and Sternal Ribs; Sternum.—The

dorsal vertebræ number five; the anterior one articulates with the last cervical and the last dorsal with the first sacral. Although the dorsals of this bird fit very snugly to each other, it requires no further masceration to separate them from one another than it does to remove the ribs from their attachments. This close interlocking, however, greatly diminishes the movement of this division of the spinal column, bestowing upon it a rigidity only exceeded by the anchylosed vertebræ of the sacrum; yet, it must be understood, they do enjoy, in this Owl, a considerable degree of movement, especially laterally. The neural spines have here attained their maximum development, forming, when taken together, an elevated and compressed median crest, with a thickened summit, and having a firm hold upon the remainder of the vertebræ below. Taken separately, the last is the smallest, the fourth next, and the second and third the largest. Their anterior and posterior borders are concave, allowing, when articulated, spindle-shaped apertures to exist among them, while their summits are produced backward and forward, thickened and wedged into each other. This wedging is performed in the following manner: The posterior extremity of the crest forming the summit of the neural spine of the first dorsal divides and receives the anterior extremity of the crest of the second. This same arrangement exists between the second and third, and at the summit between the third and fourth, immediately below the junction, also divides for a little distance and receives the edge of the posterior rim of the third, just beneath the union of the crests. This latter method of joining is feebly attempted between the fourth and last. The neural canal is nearly cylindrical in the dorsal region, its calibre being less at the sacral extremity and rather compressed from side to side, as are the centra as we approach that end, each one being a little more so than its neighbor beyond. Viewing these five vertebræ from above in the articulated skeleton, we observe the spinous crest already described; we are struck with the regularity with which the postzygapophyses overlap and adjust themselves to the prezygapophyses from before backward, the facets of the former facing downward and outward, the opposed surfaces of the latter facing upward and inward. The transverse processes are horizontally compressed and rather broad; the neural spines jut from them at right angles from points about their middles. There is an inclination for the latter to be directed slightly backward as we near the sacrum. The diapophysis of the

first dorsal is the shortest and stoutest, that of the last the most delicately constructed. Superiorly, these processes support metapophysial ridges at their extreme outer borders. These ridges on the transverse processes of the first dorsal are the largest, being rounded at both ends, and extending a little backward and forward, but far from touching the ridge either in front or behind them. The metapophysials of the last dorsal are smaller, being sharp, styliform and project only forward, not touching, however, the transverse processes in front of them.

On the intermediate vertebræ they change gradually between these two extremes, but in no instance meet the transverse processes of the vertebra before or behind them, and thus constitute an additional aid to the rigidity of the back, as it does in other species of this family and in many other birds. The centra increase in depth beneath the neural canal the nearer they are to the sacrum. In the first dorsal the body measures about one millimetre, the vertical diameter of the canal being three; in the last dorsal it equals the diameter of the canal. The interarticular facets are in the vertical plane, with their concavities and convexities opposed to each other, as they were described when speaking of the last cervical vertebræ. The bodies are about of a length, constricted at their middles and expanding toward their extremities. The first two dorsals each bear in the median line, beneath, a hypapophysial process of considerable size, affording abundant surface for attachment of some of the muscles of the neck. The process of the first dorsal has one common trunk, with a compressed midprong and two lateral and pointed subprocesses. The second dorsal possesses a single long hypapophysis, quadrate in form, dipping into the chest further than the first. There is not a trace on the remaining dorsals of this appendix. Parapophysial processes, so prominent in nearly all the cervicals, afford in the dorsal vertebræ simply articulating facets for the capitula of the ribs situated just within the anterior margin of the neural canal of each centrum, never extending to the vertebræ beyond, forming the demi-facet of andranatomia. Immediately above these facets, on either side, may be noticed a group of pneumatic foramina, of various sizes and shapes, and again, anterior to these foramina, the rim of the body of the vertebra for a limited distance becomes sharply concave, being opposite to a like concavity in the next vertebra, the two, when opposed and articulated, forming the oval foramen for the exit of the dorsal nerves.

Elliptical articulating facets for the tubercula of the ribs, looking downward and outward, are seen on the inferior ends of the transverse processes, with a midridge running from each facet to the base of the process, to be expanded and lost on the sides of the centra. As there are five dorsal vertebræ, so there are five dorsal ribs articulating with them and with the sternal ribs below. Each rib is attached to a single vertebra, as shown while speaking of the dorsals. The neck of these ribs become more elongated the nearer they are to the pelvic extremity of the body, the first possessing the shortest. This is exactly reversed in regard to the pedicles bearing the tubercula, being the longest in the first rib and shortest in the last. This contraction of the pedicles is progressively compensated for by the lengthening of the corresponding and respective transverse processes of the vertebra to which they belong. Viewing the ribs from the front, in the skeleton, the curve they present resembles the quadrant of a shortened ellipse, the vertex of the major axis being situated at the base of the neural spines; viewed laterally, the curve is sigmoidal, though a much elongated and shallow one, with the hæmapophysial extremity looking forward and the facet of the tubercle backward. The first rib is the shortest and generally, though not always, the broadest; the last being the longest and most slender, the intermediate ones regularly increasing in length and diminishing in breadth from the first to the last. In form, the ribs of this Owl are flattened from side to side, widest in the upper thirds, narrowest at their middles and club-shaped at their lower extremities, where they articulate with the sternal ribs by shallow facets. On the inner surfaces we find the necks produced upon the bodies as ridges, running near their anterior margins and becoming lost at about the junction of the upper and middle thirds in the body of the rib. Pneumatic foramina, from two to three in number and of considerable size, are found just within the commissure between neck and tubercle, posteriorly. All the vertebral ribs bear a movably articulated *epipleural appendage*, each resting in a shallow cavity designed for it upon the posterior borders. They leave the rib at right angles, but soon turn upward with a varying abruptness. The appendage of the first rib is situated lowest of any on its rib, that of the last the highest; the facets of the others are found in the line joining those of the first and last. They all make acute angles with the bodies of the ribs to which each belong, above their points of insertion. The angle made by the last is the least, and it

increases to the last. The epipleurals of the leading ribs are the widest and generally the longest. The one on the second rib in a skeleton of this bird now before me is as wide as the rib at the point from where it starts; the one on the last rib being always the smallest.

Clubbed at their superior extremities, each one overlaps the rib behind it, and in this manner adds stability to the thoracic parietes, which is undoubtedly the function these little scale-like bones were intended to fulfill. The sternal ribs connect the vertebral ribs with the sternum. There are six of them, one articulating with each vertebral rib, and having a concave facet to receive it, while the last meets the sacral rib above and articulates with the posterior border of the fifth below. The first one is the shortest and most slender of all; the fifth is the longest. With the exception of the last, their superior ends are enlarged and compressed from side to side, while below their middles they become smaller; then turning upon themselves, suddenly enlarge again, so as to be flattened from before backward, when each terminates by a transverse articular facet for articulation with the sternum. Quite an interspace exists between their facets of articulation. They all make a gentle curve upward just before meeting their respective ribs. The sternal rib that articulates with the sacral rib is inserted in a long, shallow groove on the posterior border of the sternal rib that articulates with the last dorsal one, but does not meet the sternum, simply terminating in a fine point on the posterior border of the sternal rib mentioned. From before backward the sternal ribs make a gradually decreasing obtuse angle with the vertebral ribs, while the angle they make with the sternum is a gradually increasing acute from the fifth to the first. On the anterior surfaces of their expanded sternal ends are to be found on each a minute pneumatic foramen or two. The anterior third of the lateral borders of the sternum is the space allotted for the insertion of these bones.

The Burrowing Owl being a bird not possessed of any considerable power of flight, or the necessity of having that flight ever long sustained, a circumstance arising from the life it has come to lead, we would naturally expect to find, in the course of a study of its anatomy, those characteristic modifications of the various systems which pertain to species of the class in which that gift has always been a secondary consideration. Nor are we disappointed in this expectation, for a glance at the size of the sternum of this Owl,

when compared with the remainder of its skeleton with regard to areas for muscular attachments, reveals to us the disproportion of the surface supplied by that bone for the attachment of the pectorals. That its dimensions are relatively contracted is proved by actual comparative and proportional measurements of the bones with other species of its family, individuals of which, at the best, are not noted for their powers of flight, as a rule, and of a consequence the sternum does not present so prominent a feature of the skeleton as it does in other species of the class *Aves* where vigorous flight is habitual. The concave dorsal aspect of the body is smooth, being traversed in the median line by a very shallow groove that lies immediately over the base of the keel. This groove terminates, within five millimetres of the anterior border, in a litttle depression, at the bottom of which are discovered pneumatic foramina, two or more in number, leading to the anterior vertical ridge of the carina beneath. Other minute openings for the admission of air into the interior of this bone are seen among some shallow depressions just within the costal borders. The bone does not seem to be as well supplied in this respect as it is in some other Owls. The costal borders supporting the transverse articular facets for articulation with the sternal ribs occupy anteriorly about one-third of the entire lateral border on either aide. At the bases of the majority of the depressions that occur between these facets are found other pneumatic foramina. The anterior border is smooth and rounded, with a median shallow concavity occupying its middle third. At its extremities, laterally, the costal processes arise with a general foward tendency at first, but with their superior moieties directed backward. The costal borders terminate at the posterior borders of these processes at a higher level than the anterior margin does at their anterior borders. The coracoid grooves are just below the anterior border. They are deep, continuous with each other, having a greater depth behind the manubrium in the median line than observed at any other point. Their general surface is smooth and polished, looking upward and forward, and lying principally in the horizontal plane. They melt away into the body of the bone laterally at points opposite and not far distant from the posterior articulations on the costal borders. The margin that bounds them below is sharp, travels at right angles from the median line, at first to a point posterior to the costal processes, then making a little dip downward, then again curving up-

ward, disappears gradually with the groove it bounds. That portion of it from the point where it changes its direction to its termination is described by authors as the subcostal ridge. The manubrium, occupying its usual position in the middle line, is comparatively small, quadrate in form, compressed below, slightly notched and flattened above, its posterior surface forming the inner anterior surface of the coracoidal groove. All the borders bounding the posterior parts of the bone are sharp; the lateral ones, taken from the apices of the costal processes to their other and lower terminations, are concave. As is the arrangement generally among Owls, the xiphoidal extremity of the sternum is four-notched, two on either side, the outer notches being the deeper. Both have rounded bases, and the processes that separate them are ample and possess rounded extremities. The border upon which the keel ends posteriorly is square, though we have met with specimens in which it was slightly notched in the median line. The body is oblong, and if we include the xiphoidal processes on either side, has a length half as long again as its width. The ventral and convex surface, like the dorsal, is smooth and presents but two points for examination. The pectoral ridge, faintly marked throughout its extent, originates on each side at a point near the outer borders of the coracoid grooves, running inward and backward, and dies away at the base of the keel near its middle. This little ridge denotes the line between the pectoralis major and minor. The keel is moderately well developed, the distance from the base of the manubrium to the carinal angle being equal to the distance from the same point at the base of the manubrium to the base of either costal process or outer anterior sternal angle. It is compressed, smooth and thin, but its stability is greatly aided by the carinal ridge on either side, which commences strong and well-marked at the base of the manubrium, just within the anterior border, running parallel with the latter, and disappears as it approaches the carinal angle. The anterior border of the keel is sharp and concave; the inferior border is convex, with the edge slightly thickened. The point of intersection of these two borders anteriorly is rounded and forms the carinal angle. The inferior border expands posteriorly, and the keel terminating a short distance before arriving at the posterior sternal border, the two become blended with the surface of the body of the bone.

Sacral Vertebræ and Coccygeal Vertebræ.—In the sacrum of the

Owl now under consideration, with the exception of a few faint lines indicating the original individuality of the vertebræ, these bones are thoroughly anchylosed together and to the ossa innominata. From inspection of this compound bone in immature birds we find the usual number of sacral vertebræ composing the sacrum to be thirteen. The anterior face of the first possesses all the necessary elements for articulation with the last dorsal. The neural spine has a thickened crest that soon meets the ilia on either side; its anterior edge is thin, and gives attachment below to the interspinous ligament. The neural canal is circular and the prezygapophyses well marked. The articular facet of the centrum is in the vertical plane, with its curvatures similar to those ascribed to the anterior facet on the centra of the dorsals. The neural spines are broad and the transverse processes are strong and raised, with their enlarged extremities expanded upon and firmly united with the iliac bones. There is but one pair of sacral ribs, and they are free ones. Long and slender, they articulate with the first vertebra in the usual manner, but the relation is much more intimate, as they touch the diapophyses for some little distance beyond the tubercula toward the capitula. The lower extremities of these ribs are terminated by little roundish knobs, which articulate with the corresponding sternal rib on either side, described above as being inserted in the posterior border of the fifth sternal rib. Viewing the bone dorsal-wise, it is to be seen that the thickened crest of the neural spine of the first vertebra protrudes from the angle made by the ilia meeting it anteriorly to a greater or less distance. This broad and compressed crest, then continued backward, is firmly wedged between the ilia until we pass the third vertebra; at this point the ilia diverge from each other to another point just anterior to the acetabula, then converge, terminating in the posterior sacro-iliac border, within five or six millimetres of each other. The sacrum completely fills in the lozenge-shaped space thus formed from the third vertebra—first, by continued broadening and compression of the neural spine, that soon becomes one with the others of the series; and secondly, by the expanded extremities of the di- and parapophyses, the processes themselves also taking due part. The integrity of the surface is unbroken, save posteriorly, where a few pairs of foramina exist among the expanded transverse processes, increasing in size from before backward. Anterior to a line joining the acetabula the surface is in the

horizontal plane; posterior to this line there is a decline, which declination is accepted also by the innominate bones; this gives the entire pelvis a shape that seems to be characteristic of a majority of both the diurnal and nocturnal *Raptores*. The "ilio-neural" canals here present open but small apertures posteriorly at about the point where the ilia commence to diverge, passing obliquely downward and forward; their anterior openings are large enough to allow a view of their internal walls. The neural spine that divides them throughout is compressed from side to side; the ilia which form their outer boundaries are convex; the neuro-spinal crest forms the roof, the basal surface being deficient, formed merely by the spine-like di- and parapophyses of the vertebræ and the confluent neural arches. Now, a line drawn mesially on the centra below, from the first centrum to the last, gradually rises until opposite the anterior borders of the ischiadic foramina, then curves rather abruptly downward to its termination. The centra of the first two or three vertebræ are compressed from side to side to such an extent as to cause them to appear wedge-shaped, the common apex or edge being below; after that, however, they rapidly broaden, become compressed vertically and more cellular in structure. They are very broad from the fourth to the ninth, inclusive, then as rapidly become contracted as they approach the coccyx. Minute but numerous pneumatic foramina are seen at or near the usual localities. The largest foramina for the exit of the roots of any pair of sacral nerves is generally in the fifth vertebra; they decrease in size as they leave them either way. In the young only the last few of these foramina are double; they are all double in the adult, and placed one above another, a pair on the side of each centrum at their posterior borders. The tranverse processes of the anterior five sacral vertebræ are thrown out against the internal surfaces of the ilia, to which they are firmly attached, and act as braces to hold the engaged bones together. The parapophyses of the first form facets for articulation with the sacral ribs; the second and third have none; in the fourth and fifth they also act as braces in the manner above described, joining the ilia just before their divergence commences. Reliance seems to have been placed entirely in the completeness of the sacro-iliac union in the last vertebræ, for the apophysial struts terminate in that portion of the pelvic vault formed by the sacrum itself, except in the last two vertebræ, where the parapophyses abut against the iliac borders. The

parapophyses of that vertebra which is opposite the acetabula are prominent, they being long and ample, reaching to the border and reinforcing that part of the pelvis that requires it the most, the vicinity of the leverage for the pelvic limbs. In other *Strigidæ* several apophyses are thrown out at this point. The posterior opening of the neural canal in the last sacral vertebra is subcircular, its diameter being about a millimetre in length. This vertebra also possesses small postzygapophyses, looking upward and outward for articulation with the prezygapophyses of the first coccygeal vertebra; the articulating facet of the centrum is also small, long transversely, notched in the median line, the surface on either side being convex. At every point where the sacrum meets the iliac bones union is firm and complete, though both upon the internal and external surfaces the sutural traces are permanently apparent. The anterior iliac margins, as they diverge from the sacral spine, form an acute angle, concave forward; they have a well-marked rim or border, nearly a millimetre in width, raised above the general surface of the bone, which disappears on the outer borders as we follow them backward. The two anterior and outer angles overhang the sacral pair of ribs and fifth or last dorsal pair. From these last the marginal boundaries, which necessarily give the bones their form, are produced backward and outward to a point opposite the centrum of the third sacral vertebra, then backward and inward, forming at the above points two lateral angles. From the apices of the two lateral angles to where the borders terminate on either side in front of the acetabula with the pubic bones, the direction is such as to form a concavity on each side; the line adjoining the bases of these concavities, points opposite the posterior openings of the ilio-neural canals, being the narrowest part of the pelvis. The upper and at the same time the inner margins of the bones in question form the anterior and median angle at first approach, soon to diverge from each other and form the gluteal ridges and borders of those scale-like projections of the posterior portion of the ilia that overhangs the acetabula. Produced now as the "gluteal ridges," they tend almost directly backward, though very slightly inward, to terminate in the ischial margins. The preacetabular dorsal iliac surfaces are generally concave, while the postacetabular, and at the same time that surface which occupies the higher plane, is flat, having a slope downward and backward, with a ventral reduplication after forming the rounded and concave posterior

boundary of the pelvis. The preacetabular superficial iliac area is nearly double the extent of the postacetabular. The antitrochanterian facets that surmount the cotyloid cavities have the usual backward direction, though their surfaces look downward, outward and a little forward. The external surfaces of the ischia look upward and outward, having just the reverse direction ventrally. Posteriorly these bones are produced beyond the ilia into finely-pointed extremities, tending to approach each other. The slender pubic bones, after closing in the obdurator foramen on either side, touch and unite with the inferior borders of the ischia as far as the pointed ends of the latter, beyond which they are produced nearly to meet behind. The circular and thoroughly perforated acetabula are formed in the usual manner by the three pelvic bones. They have a diameter of about three millimetres, and their circumferences are in the vertical plane. The ischiadic foramina are elliptical and large; they are, as usual, posterior to the acetabular and above the obdurator foramina. These last are also elliptical and about one-third the size of the others. Viewing the pelvis ventralwise, we observe, in addition to points mentioned when speaking of the sacrum, the reduplication of the ilia, forming pockets behind and internally, that open outward through the ischiadic foramina and inward into the general pelvic cavity. The narrowest part of the pelvis measures 1.2 centimetres, the widest 2 centimetres, being taken between the iliac projections over the acetabula; the average length, including anterior neural spine, is 3 centimetres. Pneumatic foramina occur in the shallow anfractuosities, between the antitrochanters and gluteal ridges in the ilia. None of the caudal vertebræ are grasped by the pelvis, the posterior extremity of the sacrum always assisting to form the posterior pelvic border. The usual number of these vertebræ is seven, though occasionally an additional one is found, making eight in some individuals. This enumeration does not include the modified and ultimate coccygeal vertebra, the pygostyle. They are all freely movable upon one another, and the first upon the last sacral vertebra. The articular facets upon the centra vary in shape throughout the series; that upon the first is long transversely, with a double convexity so arranged as to accommodate itself to the one on the extremity of the sacrum; they soon become uniform, to pass to the subcircular one existing between the last vertebra and the pygostyle, on which it is concave.

The pleurapophyses and parapophyses are very rudimentary or entirely suppressed. Each vertebra bears a prominent neural spine, which, from the first to the sixth, inclusive, is bifurcated; in the last two it appears as a mere primitive knobule. The transverse processes are all deflected downward and outward, very small in the first and still more so in the last; are largest in the fifth and sixth. Prezygapophyses are well marked; they reach forward and articulate with the feebly developed postzygapophyses. In a few of the posterior segments there appears to be an effort on the part of the neurapophyses to overlap the vertebra next beyond them. The neural canal is pervious throughout, commencing in the first with a calibre equal to that in the end of the sacrum; it gradually diminishes and terminates in a minute, blind conical socket in the pygostyle. Hypapophyses are produced downward in a few of the ultimate vertebræ. They hook forward and articulate with the centrum of the vertebra next beyond them. Sometimes they are observed to be free, or rather resting upon a facette on the anterior margin of one centrum and extending over to the anterior margin of the centrum of the vertebra anterior to it, to meet a similar facette, as a tiny styliform process. The spinal column is completed posteriorly by the pygostyle—that ploughshare-shaped segment that articulates with the last coccygeal vertebra. Above its cup-shaped facet this bone arises as a laterally compressed plate, extending backward and bifurcated at its extremity, as if to imitate the neural spines of the vertebræ of the series of which it is an ultimate appendage. Below the facet it projects forward and completes the median sequence of hypapophyses of the centra, being rather larger than any of them. The posterior curve is simply inflected downward and forward from its apex.

The Scapular Arch.—The three elements that constitute this arch are all represented, and all independent or free bones; the coracoids articulate with the sternum and scapulæ; coracoids and clavicle, connected by ligaments, lend their share to form or strengthen the shoulder-joints. The coracoid, comparatively large and strong, forms in the usual manner an arthrodial joint of restricted movement with the sternum, its lower end being in the coracoid groove on the anterior part of that bone. The inner angle of its base is about two millimetres from the mesial line, and four millimetres intervening between it and its fellow of the opposite side in the groove. This extremity is broad, its outer angle

being beneath the third sternal rib at its point of meeting the costal border; it is compressed from before backward. The articular facet, looking downward, backward and a little inward, is transversely concave, with a slight dividing ridge running anteroposteriorly, converting the general concavity into two smaller ones. The coracoid, when in position, is produced upward, forward and outward, making, with the vertical line through its base, rather an acute angle. A limited portion of the middle third of the bone only is subelliptical on section and at all shaft-like, due to the fact that the coracoid in this bird being perhaps less than the average length as compared with the size of the bird, and, secondly, to the unusually enlarged extremities, features observable, more or less, in *Raptores* generally. The anterior groove of the upper extremity, that is arched over by the head of the clavicle above, is deep and occupies fully the upper third of the bone. The coraco-clavicular process springs, thin and compressed, from the inner side of the shaft of the bone, at junction of upper and middle thirds, to turn upon itself, so as to be projected upward, forward and a little outward, terminating with an elliptical facet for articulation with the clavicle. The upper border of this process is concave lengthwise and articulates throughout its extent with the inferior margin of the acromial process of the scapula. The lower and thin edge of the coraco-clavicular process tends obliquely downward, to be lost on the inner surface of the shaft of the bone near its middle. The outer wall of the anterior groove is formed by the coracoid itself, the process just described being really nothing more than a wing-like extension forming the inner boundary of the groove in this bird; it terminates above both clavicle and scapula in a rounded tuberous head. Below this head, anteriorly and still more inwardly, the coracoid affords a vertical, elongated facet for the clavicle, while behind, looking a little outward, is the concave elliptical facet that constitutes about one-third of the glenoid cavity for the humerus. Internal to this last, and running first directly upward, then making a right angle and continuing forward, a little upward and outward, the last direction being the upper margin of the coraco-clavicular process, is another facet, for the scapula. Behind and below, this bone displays one or two lines and depressions, boundaries of muscular attachments. In the middle of the anterior groove, opposite the base of the coraco-clavicular process, the

shaft of the bone is perforated; this perforation is elliptical lengthwise with the shaft and passes directly through to make its appearance on the posterior convex surface just below the scapula. This foramen transmits a branch of that cervical nerve coming from between the twelfth and thirteenth cervical vertebræ. This nerve branch, after passing through the bone, is distributed to the under surface of the pectoralis minor muscle, and its filaments ascend among its fibers. This foramen is observable also in other Owls, as *Bubo virginianus*, and in some of the diurnal *Raptores*, as in *Accipiter cooperi;* in very many birds it is absent. This scapula presents little that is unusual in that bone among the class generally. It lends the additional two-thirds of articular surface to form the glenoid cavity with the coracoid; internal to this the acromion process extends forward, touching the coracoid as described and having a limited bearing on the clavicle. Posteriorly its blade-like length is produced, expanding, turning slightly outward, to terminate in an obliquely truncate extremity, with its point over the second dorso-pleurapophysial interspace.

What the scapula lacks in interest is amply made up by the changes observed in the last bone of the group, the clavicle. This element is broad above, much compressed from side to side throughout; it spans the anterior groove and touches the scapula as described above, rapidly diminishing in size as it is produced downward and inward by a gentle curve toward the fellow of the opposite side. The upper extremities in adult birds are separated by an average distance of 2.3 centimetres. If the sternum pointed to feebleness of flight in this little Owl, it is still further carried out by the ill-developed clavicles, which constitute that arch in birds when they are thoroughly and firmly united below, that assists to resist the pressure of the humeri when the wings are depressed in flight, and send them back to their former position after the completion of the action. In an old male *Speotyto*, we find this bone to be simply a pointed styliform process. In other individuals, however, and adults, too, the clavicle does not even attain to the length there shown; but, as if to bid defiance to any invariable rule governing its development, we again find in very young birds cases where it becomes confluent with its fellow, forming a broad U-shaped arch, though never a very strong one. In a case of this kind the bone was finely cancellous throughout, with an extremely attenuated layer of compact tissue outside, scarcely covering it.

In the figures given in my memoir on *Speotyto* and other individuals like it, the clavicles were pneumatic. Again, in both young and old, it may have any of its lower parts completed by cartilage; it never displays a mesial expansion of bone at the point of confluence. As already shown, the superior entrance of the anterior groove on the coracoid is a complete circuit, formed by the three bones of the group. The head of the coracoid overhangs it above; next below is the clavicle, closing it in anteriorly; lowest of all the scapula behind. A plane passing through the superior margins of this aperture would look upward, inward and backward. All the bones of the scapular arch are pneumatic, with the exception sometimes seen in the clavicle; and the foramina, to allow the air to enter their interiors, look into the enclosed groove of the coracoid just described. In the scapula the foramen is usually single and in the acromion process; single again in the clavicle, it is seen in the broadest part of the head, while in the coracoid there is generally a group of these little apertures, situated in the depression on the surface that overhangs this entrance to the coracoidal groove.

As in many others of the family, in common, too, with not a few of the diurnal *Raptores*, this Owl possesses an os humero scapulare, of the usual form, that increases the articular surface of the shoulder-joint for the humerus.

Of the Upper Extremity.—The upper extremity consists of ten distinct bones in the full-grown bird, omitting minute sesamoids that may possibly exist. These are the humerus of the arm, the radius and ulna of the forearm, two free carpels, the metacarpal and four phalanges. The humerus is a long, extremely light and smooth bone, and when viewed from above in its position of rest, with the wing closed, it reminds one of the curve in the small italic letter *f*, being concave above toward the scapula. And this bone is so twisted that this same curve is exhibited, though not quite as well marked, when viewing it laterally. The humerus is 5.5 centimetres long, subcylindrical on section at midshaft, at which point a minute aperture exists for the passage of the nutrient vessels that are distributed to the osseous tissue and its internal lining. This foramen enters the bone very obliquely, its external orifice being nearest the proximal extremity. This end is well expanded, and surmounted above by a strongly developed radial crest that overhangs the shaft slightly toward the palmar aspect. It occupies a

line on the bone from the articular facet for the shoulder-joint to a point one-third down the shaft. The ulnar crest, or lesser tuberosity, encloses quite an extensive fossa below, which acts also as a partial screen to the pneumatic foramina, for the humerus is highly pneumatic. These foramina usually consist of one circular opening, surrounded by a group of many smaller ones. In young birds a very large foramen is generally present; this closes in as age advances. Between the two tuberosities is the vertical and elliptical convex facet for articulation with the glenoid cavity of the shoulder-joint, constituting the "head of the humerus." The radial crest displays palmad, a ridge for the insertion of the tendon of the pectoralis major. The distal end of the humerus is also expanded in the vertical plane and gently convex anconad—the reverse condition of the proximal extremity. It presents for examination the articular facets for the ginglymoid joint it forms with radius and ulna and the superior and inferior condyles. The larger, and at the same time the superior, of these two facets is intended for the cup-shaped depression in the head of the radius, as well as a portion of the articular surface on the ulna. It is ovoid in form, and placed obliquely on the bone, the inferior end of the long axis of the oval being situated the nearer the proximal extremity of the shaft. This facet is separated from the trochlea surface for the ulna by a well-marked depression; this latter is a knoblike tubercle when compared with the radial facet. The condyles and the entire articular surface are about in the same plane posteriorly—that is, neither increases the length of the bone one more than another. Passing from the trochlea surface for the ulna toward the inner aspect of the shaft, there is to be observed a shallow depression, which corresponds to the olecranon fossa of human osteology, and in full extension of the limb allows room for that process of the ulna in this bird. The radius has an average length of 6.6 centimetres, and the ulna a corresponding length of 6.8 centimetres, so that their distal extremities when articulated, as we examine them in the closed wing, extend beyond the head of the humerus. In this position also the radius occupies a higher level than the ulna, and is the innermost bone of the two. The radius is slender, the transverse diameters of its subcylindrical shaft varying but little throughout its extent, though its extremities are expanded. From the elbow-joint, when the two bones are in position, it at first diverges from the ulna at a moderate curve, to

approach that bone again to nearly absolute contact at the junction of middle and distal thirds by a more gentle curve; from this latter point it lies parallel with the ulna to the wrist. The head of the radius is elliptical, being crowned by a depression for articulation with the oblique facet on the distal end of the humerus. Beyond, below, and to the outer aspect of this facet is another of similar form, though convex, for articulation with the ulna, while still more advanced toward the distal end we find the bicipital tuberosity, and, beyond, the minute nutrient foramen, all of the bones beyond the humerus being non-pneumatic. The distal extremity of the bone in question is terminated by a fanlike expansion that caps the ulna and articulates by its anterior convex margin with the radiale of the wrist. It is marked above by the longitudinal groove for the tendon of the extensor metacarpi radialis longus. The shaft of the ulna is nearly three times as large as that of the radius. Its outer half is straight, its inner curved toward the humerus, thereby increasing at the proximal moiety the interosseous space by the assistance of the opposite curve made by the radius. The stronger end is the one involved in the formation of the elbow-joint; here is to be observed the depression for the head of the radius, or the lesser sigmoid cavity, while the articular surface beyond that occupies the entire end of the bone, directed downward, inward and backward, presents for examination the greater sigmoid cavity, the olecranon and coronoid process, and the cavity for articulation with the oblique facet of the humerus. The greater sigmoid cavity is subcircular and of some depth; its lower and produced lip represents the coronoid process, as does its upper, better-marked and more tuberous prolongation represent the olecranon of andranatomia. Extending radiad is another concave, quadrate, articular facet for the oblique tubercle of the humerus, as the first-mentioned concavity articulates with the ulnar tubercle or trochlea. A little beyond this articular surface are various small tuberosities and depressions for the origin and insertion of muscles. Approaching the wrist the shaft is seen to be generally smooth, and diminishes in calibre at junction of middle and proximal thirds in the locality of the nutrient foramen, while along its entire length at certain intervals are the slight elevations for the apices of the quills of the secondaries. The distal extremity of the ulna enters into the formation of the wrist joint; it is not nearly so large as the proximal end. The articulating sur-

face has a deep mesial cleft in the vertical direction, limited externally by an elliptical curve, internally by a double tuberous knob for articulation with the irregularly formed ulnare of the carpus, while above is a roughened surface that is covered by the expanded end of the radius. The os prominens is not large in *Speotyto*.

The carpus in the adult is composed of the ulnare and radiale. The radiale articulates with radius, os magnum and ulna. The radial articulation is a rather deep and elliptical concave facet, its lower border gliding over the ulna, while the distal end of the radius plays in the concavity. The opposite face of this six-sided little bone is also smooth, and is a nearly flattened surface that articulates with os magnum. The upper and lower surfaces, as well as the ends, are simply roughened and fashioned to give the proper form to that part of the joint into which it enters, and for the attachment of ligaments. Os magnum has become confluent with the mid-metacarpal, forming its trochlear surface for articulation with radiale, ulnare and ulna. The ulnare is an extremely irregularly shaped bone; it appears to be rather the larger of the two free carpals, and is the lower in regard to position. It articulates with ulna and os magnum simply. Its outer ulnar facet is elliptical and shallow, monopolizing the entire face of the bone; its inner facet is very irregular, being formed so as to accommodate itself to the ulnar tubercles, with which it articulates. Projecting toward the metacarpus, this little bone has two prongs or limbs, the inner aspect of the extremities of each possessing a subcircular facet that articulates, the outer and shorter limb with the internal trochlear margin of os magnum, on the same side; the inner and longer limb straddles the metacarpal and glides over the surface, during movements of the joint, at a point about where magnum becomes confluent with mid-metacarpal. The ulnare has also attached to it ligaments that enclose the wrist-joint beneath—capsular ligaments of the carpus.

The metacarpus is formed in the usual manner, by the amalgamation of the pollex, medius, index and metacarpals, the first, second and third respectively. It is 3.3 centimetres long, articulating with radiale, ulna and ulnare at its proximal extremity by means of os magnum, that has become anchylosed with mid-metacarpal and the phalanges at its distal end. The first or pollex metacarpal is short, and fused with the second just anterior to the boundary of the trochlear surface of os magnum; it makes an

angle with the shaft of the second metacarpal, its extremity being directed upward. At its base, close to the shaft of mid-metacarpal, it bears a uniform facette for articulation with the thumb, a free, three-sided, pointed little bone, about nine millimetres in length. The second metacarpal is straight; its enlarged proximal extremity is formed chiefly by the confluent os magnum; its shaft is inclined to be subtrihedral, with its broadest face looking forward; its distal extremity is terminated by a knot-shaped enlargement, that is still further enhanced by the confluence with the third metacarpal. It bears a digit composed of two phalanges, the proximal one bearing on its posterior border, for nearly its entire length, a quadrangular expansion that has a raised margin, leaving a single concavity radiad; a similar concavity occurs on the ulnar side, but is there divided by a ridge sloping downward into two shallow depressions. This little bone somewhat reminds one of a cleaver, with the end of its handle attached to the metacarpus. It supports at its distal extremity the second phalanx of this digit, a bone having very much the same appearance and shape as the index digit, only being longer and more pointed. The proximal ends of all the phalangeal segments are more or less expanded, in order to support the ample facets of articulation that occur among them and the metacarpus. The third metacarpal is expanded transversely above, slender below, where it falls a little beyond the medius after its confluence with it. It also has a small pointed phalanx, freely attached to its distal extremity, and lying in that recess formed by the shaft and posterior expansion of the first phalanx of the second digit. At a very early date, comparatively, in the life of this Owl, ossification is normally extended to many of the tendons of important muscles of the antibrachium and pinion.

Of the Pelvic Limb.—The lower extremity is composed of twenty distinct segments, including the patella, or just double the number found in the pectoral limb. This increase will not surprise us when we recollect the greater number of small bones devoted to the foot above those found in the hand. Its most striking feature, next to those osteological characteristics common to the family, is its extreme length, due principally to the tibia and tarso-metatarsus. All the bones of the lower limb in this species are non-pneumatic. The femur is comparatively of good size and strong; articulated in the usual manner, it measures four centimetres in length and seven millimetres across the condyles at their widest part. At the proxi-

mal extremity, externally, above the shaft, there is a flat and roughened surface, bounded above by the curved trochanterian ridge. This surface forms the major part of the great trochanter. There is no trochanter minor present. The trochanterian ridge is the highest part of the bone, when it is held vertically; it lies in the antero-posterior plane, with the femur in its natural position, the bird standing erect; from it, sloping directly inward and occupying the remainder of the summit between it and the head, is a smooth articular facet, broadest externally, merging into the globular head internally.

With the head it constitutes the articular surface for the pelvis—it being opposed to the antitrochanterian facet of the ilium, while the caput femoris plays in the cotyloid ring. The excavation for the ligamentum teres on the latter is conical and deep, consuming a good part of the bone; it is situated on its upper and inner aspect. In looking into the relation existing among head, neck and shaft of the femur of this bird, we must observe that if the straight line lying in the middle of the surface of the internal aspect of the shaft were produced upward, it would pass through the centre of the facet at the summit—if anything, nearer the trochanterian ridge than it does to the head. This facet also is notably narrower just before arriving at the head than at any other point. Again, the plane passing through the external and circular boundary of the head makes an angle of a good forty-five degrees with this line, so that with these facts in view we can hardly assert in the case of the species before us, as do some authors on comparative anatomy in describing this bone *in general*, that the head of the feumur is either nearly at right angles with or is sessile with the shaft. It would appear, though, that it has quite as much of a neck to boast of as the anatomical neck of humerus or the neck of the scapula described for man's skeleton in works on human anatomy. The shaft throughout its length, until it begins to approach the distal condyles, where it is subcompressed and expanded antero-posteriorly, is nearly cylindrical, bends slightly backward at its lower end, and offers for examination merely the intermuscular ridges, with the linea aspera feebly marked, and the nutrient foramen, all of which maintain their usual positions on the bone. At the distal extremity the rotular canal, the intercondyloid notch and the popliteal fossa are all strongly produced, giving due prominence to the condyles, internal and external, between which they form the dividing tract.

The external and lower condyle is divided in two by a vertical excavation, deepest above. Of the two facets thus formed, the inner articulates with the tibia, the outer with the head of the fibula. The external surface of this condyle is flat and continuous with the shaft. The inner condyle, broad posteriorly, has a slight depression in the surface that bounds it on the tibial side, and as a rule the usual sites for ligamentous attachments about this extremity are at best but feebly represented. The patella, encased in the tendon of the quadriceps femoris, is situated about three millimetres above the rotular crest of the tibia, anteriorly, having the form of an oblate hemispheroid with its base directed upward, the long diameter of which measures 3.5 millimetres. The tibia is the longest bone in this bird's skeleton, and at the same time, taking this length into consideration, the least curved or bent along the shaft; it has, however, a slight and appreciable gradual curvative forward that is most apparent about the junction of middle or upper thirds. Its average length, measured on the inside, is 6.7 centimetres; its extremities being expanded for articulation, above with the femur, below with the tarso-metatarsus. These expansions are of about equal dimensions, though differing vastly in form; in this respect being unlike some of the diurnal *Raptores*, in which the distal condyles constitute the smaller end of the bone.

Among the most important points presented for examination about the head is the articular surface that crowns it above for the condyles of the femur. This is subquadrate in form, uneven, highest at the anterior and inner angle, sloping gradually to the opposite one, bounded almost entirely around by a raised margin, that is most feebly developed posteriorly and at a point anterior to the head of the fibula, where it is absent. In front, this border may be nominated the rotular or epicnemial ridge, though it is no more prominent there than at any other point; but in many birds it is so produced as to form a process of some size, to which these terms are applied. Externally and posteriorly the margin is roughened for the attachment of ligaments that bind the head of the diminutive fibula to this bone. In the middle of this articular surface is to be seen a tuberosity, on either side of which are the depressions for the femoral condyles. Produced downward, anteriorly, from the rotular ridge are the cnemial ridges; these have their crests bent slightly forward, and they merge into the shaft below, abreast the superior point of the fibular ridge. Of the two, the outer or

ectocnemial is the shorter—that is, it does not extend so far down the shaft as the inner or procnemial. They have between them an ovate concavity, with the larger end above, the lower end subsiding upon the shaft with the ridges themselves. The vertical elevation on the external aspect of the shaft for articulation with the fibula runs down the side but a short distance; a little below its abrupt termination may be observed, in a line with it, the nutrient foramen, entering very obliquely from above downward. After leaving the fibular ridge as far as the point where the bone begins to expand transversely at the distal extremity, the shaft is remarkably smooth and nearly cylindrical. This transverse and distal expansion is checked, both anteriorly and posteriorly, by abruptly meeting the distal condyles, the point of meeting perhaps being rather the higher behind. The condyles, differing but little in size, are singularly uniform as to shape, with their curved surfaces downward, being flat on their outer aspects, with a raised rim bounding them in each case. They stand out prominent and apart. Anteriorly their convex surfaces are the widest, behind they slightly approach each other, and the articular convex surface is narrowest on the outer condyle. The intercondyloid notch is deep, and appears equally well marked throughout its extent. Immediately above it, anteriorly, there is a deep triangular depression; another and more shallow one is found behind in the corresponding locality. Up the shaft a short distance on the inner side, anteriorly, is a little tubercle, to which is attached the ligament that binds down some of the strong tendons of the extensors. This ligament crosses the anterior triangular depression mentioned above obliquely, to be inserted near the external condyle superiorly. This is the arrangement also in *Bubo virginianus*, but in some of the Hawks this ligamentous bridge has become thoroughly ossified, forming a strong bony band across the concavity in question. It is interesting to remark here, however general the rule may be as applying to the diurnal and nocturnal *Raptores*, that whereas this band is ligamentous in the tibia in some of the Owls, a bony one fulfilling the same function is found in them just below the head of the tarso-metatarsus; these conditions are just reversed among some of the Hawks. Usually, in old birds of this species, the fibula is firmly united to the entire length of the fibular ridge of the tibia, a union almost amounting to anchylosis. Arching outward, its head, surmounted by an antero-posteriorly elongated

facet, rises a little above that bone at the point where it is attached to it by ligament. This is the larger part of the shaft in regard to size. Below the ridge this bone becomes simply a delicate little spine, that merges into the shaft of the tibia at about the junction of middle and distal thirds, though it may be traced after this as far as the middle of the outer condyle, where it terminates by a minute tubercle. The head is notched externally, near the centre, and has lodged at that point a small sesamoid that is in the lateral ligament of the knee-joint. Posteriorly on the shaft, about midway down the superior tibio-fibular articulation, we observe a small tubercle for the insertion of the tendon of the biceps. The long segment that exists between the tibia and the phalanges of the pelvic limb is the bone tarso-metatarsus, or the confluent metatarsals of the second, third and fourth toes with certain tarsal bones at its proximal extremity. It measures down the anterior aspect, mesially, 4.6 centimetres, and has its extremities enlarged for articular purposes, in common with other long bones of the skeleton. At its proximal end the bone presents superiorly two concave articular surfaces for the condyles of the tibia. They appear nearly on a level with each other, the bone being held vertically. The inner and larger of the two is elliptical in outline, antero-posteriorly; the outer and smaller is fashioned off behind by a tuberous process, directed upward and outward. Between these two surfaces arises a prominent tuberosity that in the articulated limb enters the intercondyloid notch of the tibia quite accurately, and is intended for ligamentous attachment. Anteriorly and internally a groove exists that runs down the shaft, to disappear a little above its middle. This canal is deepest immediately below the articular expansion, and is here bridged over by a little arch of bone, a millimetre in width, that serves to bind down and hold in its proper place the tendon of the long extensor of the toes. Posteriorly there is a much deeper and longer tendinal canal that extends the entire length of the shaft, being shallowest at the middle and most capacious at the proximal extremity; this is bounded above and internally for a short distance below the head of the bone by the hypotarsus, a thin lamina of bone that has a foramen near its base; this process is surmounted by an elliptical and compressed tuberosity, placed vertically. Above, the opposite wall of this groove is also thin, and extends in common with the calcaneal process, directed backward. There are two other foramina

seen at this end of the tarso-metatarsus; one just at the external termination of the bony bridge mentioned above, and the other outside and a little above it. Their posterior openings are immediately behind the anterior ones, or, in other words, they do not pierce the shaft in any way obliquely. The shaft of this bone is notably square on section for the major part of its extent, being encroached upon, however, both before and behind, by the aforesaid tendinal grooves. The tendons, especially those that occupy the posterior canal, are very prone to ossification, forming quite sizable bones in the adult, the largest of these being equal to the fibula in bulk, exclusive of course of the head of that bone, and not being as long. Returning to the tarso-metatarsus, we find at its distal extremity, for examination, the trochleæ that articulate with the rear segment of all the toes except hallux. Viewing this end with the bases of these trochleæ toward one, we find the general outline made by them to be crescentic, with the horns having a tendency to approach each other behind. The outer trochlea is the highest and longest from before backward; the other two are about on the same level, the inner one having a posterior and internal process, while the middle one is possessed of a median cleft traversing its face antero-posteriorly. They are sharply divided from each other by narrow slits that extend up as far as the articulating part, and are continued on the anterior aspect of the shaft for a short way as delicate groovelets. A foramen is situated in the outer of these that gives passage to the anterior tibial artery, and is comparatively larger than is usually seen in the Owls. Behind, the tendinal groove expands, and is bounded distally by the concave border formed by the trochleæ. Upon its internal margin, just above the extremity of the bone, it shows an elongated but feebly marked depression of about three millimetres in length. This facet articulates with the os metatarsale accessorium, which is joined to the bone by ligament. This little bone in this bird has an average length of four millimetres. It is twisted upon itself, and bears upon one border a convex, smooth surface for the tarso-metatarsus, while distally it has an articulating surface, resembling more the mid-trochlea than any other, for the proximal segment of the hallux. Above it is sharply grooved for the tendon that goes to that toe. The toes are four in number, and their joints follow the rule that governs the greater part of the class *Aves*—that is, first, second, third and fourth toes have two, three, four and five pha-

langes allotted to them, respectively. The first phalanx of the hind toe is more compressed from side to side than in the other toes, possessing more of the characteristics of the second joint. Its posterior facet, that articulates with the accessory metatarsal, fits accurately into the cleft surface seen on that little bone. Anteriorly the facet has a median groove, forming two vertical convexities for the double concave facet on the claw, with its dividing ridge. The claws are all a good deal alike, varying in size, the rear one being the most compressed laterally. They are pointed, arched and nearly conical, the horny thecæ that cover them during life only being grooved on the under side. Their proximal ends have an articulating facet for the next phalanx behind them; this is so arranged that they can be more smartly flexed than any of the other joints of the foot, due to the convex articulating surface extending well beneath on the phalanx they meet. On the under side of their proximal extremities is a tuberosity for the attachment of the flexor tendons; it has on either side, below, an oval foramen to allow vessels and a nervelet to pass to the extremities of these ungual phalanges. The first joint of the second toe, and the first and second of the third, are thickest and short, articulating internally with the tarso-metatarsus, and having their facets so arranged as to allow of motion only in the one plane. These bones may almost be said to interlock with each other, with their superior projecting processes behind fitting closely into the deep groove intended to receive them on the anterior faces of the joints to their immediate rear. The remaining phalanges of these two toes resemble the proximal segment of hallux. The fourth or outside toe possesses five phalanges, but the three innermost segments are very short, and are really nothing more than one of the middle type of phalangeal bones, such as the third on the mid-toe, divided into three nearly equal parts, the proximal and distal pieces retaining all the characteristics of that bone, while the middle segment is simply a mid-section of the shaft. This arrangement, however, together with the manner in which the proximal phalanx articulates with the long and elevated trochlea on the tarso-metatarsus, gives this toe a versatility and a power to be thrown outward and, to a limited extent, to the rear that is not enjoyed by any of the other toes, constituting as it does one of the interesting anatomical features that we find in the family *Strigidæ*.

So much then for the osteology of *Speotyto*. The account of it

I have just given above sinks far into the realm of details, but occasionally such descriptions are very useful, and it is hoped that it will be found to be the case in the present instance.

There are at my hand two skeletons of the nestlings of the Great Horned Owl (*Bubo virginianus*) that I secured from alcoholic specimens presented me by Dr. Strode, of Bernadotte, Illinois. (See Pl. X, Figs. 1–4.) They were taken by him at the time the birds were on the point of quitting the nest to shift for themselves. Some points of great interest are to be observed in either of the skeletons of these Owlets, as in them all the separate osseous elements of this part of their economy are still individualized. For example, in the skull the small yet distinct orbito-sphenoids are seen to be ossified, and the basitemporal is beautifully defined. The basipterygoid processes are as well developed as we find them to be in an old bird of the same species; while the interorbital septum is at this time only performed in membrane. On the vault of the cranium the sutures among the parietals, frontals, and squamosals are in close contact for their entire marginal lengths; this is not quite the case, however, with the bones of the base of the skull. The otic elements are likewise quite distinct, and the vomer has not as yet ossified.

Passing to the remainder of the trunk skeleton, we note the usual state of building up, by their elements, of the various vertebræ all throughout the spinal column; and find, moreover, that *three* vertebræ enter into the formation of the pelvic sacrum.

No bone at all is as yet to be detected in the sternum, although the clavicles are now quite perfectly ossified, completely united below, and the arch possesses no little strength. The remaining bones of the shoulder-girdle, as well as the ribs, are well on toward ossification, though in form they are still quite primitive.

In the wing all the elements are thoroughly independent of each other, and the structure as a whole is always brimful of interest to me. We find that the os prominens has not yet ossified, and only a tiny nodule of bone can be detected either in the radiale or the ulnare. The expanded part of the proximal phalanx of index digit is entire, and all the finger-joints are pretty well ossified.

With respect to the pelvic limb we observe that the proximal extremity of the femur presents but a club-like end, and no hint is as yet betrayed of the formation in bone of its head, neck or the trochanter. At least three bony ossicles are to be discovered in the

tarsus, as well as an ascending process of the astragulus. The latter is quite conspicuously marked. Fibula is noted for its length, but all signs of a fibular articular ridge on the side of the shaft of tibio-tarsus are still wanting. The two bones simply lie alongside of each other, faint indications of any coössification being seen only at their distal ends. Fusion is fairly well advanced among the metatarsal elements, omitting, as I do of course, the small accessory one for hallux, which, as we know, remains permanently free throughout life. Finally, the bones of the feet are seen to be in a stage of ossificatory advance well in keeping with the other elements of the limb of which I have just been speaking.

Other Owls of the United States avifauna present us with very interesting characters in their osseous systems. Upon examining a skeleton of *Asio wilsonianus* (Pl. XV, Figs. 22 and 23; also Pl. XVII, Fig. 30), we are confronted in it with a strigine skull quite different in its pattern from anything we find in *Bubo*. In conformation it is symmetrical, so far as its auricular region is concerned. Both nasal and interorbital septa are absolutely entire, and I have yet to see a skull of this species that has a perforation in either of these partitions. One of the most characteristic features is the manner in which the postero-superior margin of either orbit is broadly flattened out, while each supraorbital process is decurved, pointed and prominent, and projects over the middle point of the orbit from above. The tympanic bullæ are large and open; the postfrontal processes rather small and jutting well out from their bases. Behind these, on either side, another long spiculiform process is sent down in front of the quadrate. It is directed forward and downward. The pars plana is upon the bubonine type, and the maxillo-palatines are of fairly large size. Coming to the vomer we find it of some considerable size, being pointed in front and fused with the palatines posteriorly. Both the pterygoids and the quadrato-jugal bars are straight and unusually slender for an Owl. The pterygoidal heads of the palatine bones are conspicuously separated, a condition that throws the anterior ends of the pterygoids themselves widely apart in this skull. They are never in contact, I believe, in any Owl. *Asio* is noted for another feature in its skull—this is the peculiar flatness of the posterior aspect of the cranium, as well as its unusual width and height for a skull of its comparative size.

Finally, we are to note that the interorbital septum is relatively much thicker in the transverse direction than we find it in other

bubonine genera, as for instance *Bubo* or *Speotyto*. The post-palatine blades are broadish, flat and thin, quite unlike other Owls.

This Long-eared Owl has a mandible of the same general pattern as seen among the *Strigidæ* generally. The bone is rather light; the inturned processes of the articular ends are longer than usually seen in other species and genera; the superior margin of either ramus, near its middle, is gently curved outward; the ramal vacuity is ragged and slit-like in the longitudinal direction. Fig. 6 and Fig. 30, Pl. XVII, give a good idea of the skeleton of the trunk in *Asio*, and I would only call attention to one peculiarity here, and we are to note that the grooves on the front of the sternum for articulation with the coracoids decussate, as they do in certain diurnal Raptores. This is not the case in *Strix pratincola*, but is seen in *Bubo maximus* and other bubonine Owls.

The clavicles are firmly united below, and a coracoid is pierced through its shaft in the same manner as we found it in *Speotyto*.

The wing bones are comparatively long, and the humerus (Pl. XV, Fig. 22) alone pneumatic, and it highly so, the foramen being almost circular and flush with the general surface of the bone. I have not seen the os prominens in this species, and am inclined to believe that it is either very rudimentary or perhaps entirely absent. The expanded portion of the first phalanx of index digit is very thin, and divided near its middle by an oblique osseous ridge. We noted that it was solid and nearly of uniform thickness in *Bubo*, twice perforated in *Strix*.

Respecting the pelvic limb, the long bones of thigh, leg and metatarsus offer no special departures from those structures in ordinary Owls at large; but in the foot, attention is called to the relative lengths of the first and second phalanx of the third toe. These are subequal, to be sure, but not in the same degree as we found in *Bubo*, for here in *Asio* the second phalanx is relatively longer than the same joint in the Great Horned Owl.

Several species of the genus *Syrnium* present us with interesting characters in their skeletons.

Dr. Robert Collett has given us quite a number of good figures of the skulls of various species of *Syrnium* in his well-known memoir entitled "Craniets og Oreaabningernes Bygning hos de nordeuropæiske Arter af Familien Strigidæ," a translation of which, including additional matter and all the original plates and figures, has been published by the present writer, as stated in the Introduction,

in the *Journal of Morphology* (Boston, U. S. A., Vol. XVII, No. 1, 1900, pp. 119–176, Figs. 1–7, Pls. XV–XX). Taken in connection with all we have already recorded upon the skull of these birds in several genera, it will not be necessary to dwell upon this part of the skeleton in *Syrnium*, as the figures to which allusion has just been made will be fully sufficient to show the special characters and form of it. (See Pl. XIII, Figs. 13 and 15.) One point of note is to be observed, however, and that is in some species of *Syrnium* the skull is symmetrical, while in some others asymmetrical distortion to a moderate degree is observable. Of the first condition *S. nebulosum* is an example, and of the latter *S. cinereum* furnishes us an instance. It is symmetrical in *Pulsatrix torquatus*. (Pl. XVIII, Fig. 13.) In this genus *Syrnium* the outer pair of notches of the sternum are conspicuously deep; the manubrium is well pronounced; the coracoidal grooves slightly cross each other; the clavicles are firmly united below, and the os prominens is of some considerable size. An interesting little point is seen in the femur, where the pit in the head of the bone for the ligamentum teres is very much deeper than is usually the case among birds.

Another Owl that exhibits a peculiar asymmetry of the cranium is *Scotiapex c. lapponica;* here the postfrontal wing is thrown farther outward on the right side, something after the order found in a species of the genus *Syrnium*, to which we referred in the last paragraph.[1]

Probably the best examples of cranial asymmetry among the *Strigidæ* are to be seen among the representatives of the genus *Nyctala*, as, for instance, in *N. tengmalmi*. Here it does not involve so much the position of the postfrontal processes as it does distort the squamosal region of the skull upon either side. A skull of this bird has been nicely drawn for us by Collett, as stated above, and republished by me in the translation of his paper.

How such a condition as this asymmetry came to be evolved will probably remain one of those enigmas in zoölogy not to be solved through the researches of man. It is difficult for me to see what

[1] This statement in reference to *Scotiapex* must, for the present, be taken with caution, as the observation was made by me upon a skeleton so labeled in the United States Army Medical Museum at Washington, and I know to my cost that the diagnoses of specimens in many cases in that collection are incorrect to a degree probably unparalleled in any institution in existence. In my own collection I have but the trunk skeleton of *Scotiapex*.

especial advantage it can bestow upon the bird, or how it would better fit it for the struggle for its existence. Apparently the largest and most powerful Owls in the world have perfectly symmetrical crania; while, as I have already noted above, the largest species known to me wherein evident asymmetry is present in that part of the skeleton is *Syrnium cinereum*. On the other hand, our very smallest owls, the pygmies of the group, as *Glaucidium and Micropallas* (see Pl. XIV, Figs. 17 and 18), possess wonderfully symmetrical little skulls, barely exceeding in size the skull of a large Thrush.

Other ornithologists have invited our attention to this cranial asymmetry as exemplified by the genus *Nyctala*. As long ago as 1870 Dr. T. H. Streets, of the United States Navy, referred to it in the *Proceedings of the Academy of Natural Sciences of Philadelphia* (p. 28); and in the *History of North American Birds*, Mr. Ridgway has figured the skull of Richardson's Owl (*N. richardsoni*), showing the same character.

Nyctea nyctea (see Pl. XII, Figs. 8 and 11; Pl. XVI, Figs. 26, 28 and 29) has a skeleton that in all essential particulars closely resembles that part of the anatomy of *Bubo virginianus*. The bird clearly belongs to the bubonine section of the group.

Screech Owls, or what we call the Screech Owls in the United States, are of many species and subspecies in the fauna. They have had the genus *Megascops* created to contain them, and I have examined complete skeletons of a number of the varieties. After the bubonine order in point of skeletal structure, they yet exhibit some interesting little peculiarities of their own. (See Pl. XIII, Figs. 12 and 16; Pl. XIV, Fig. 19.)

Megascops asio trichopsis (or any of its genus) has a skull more like that part of the skeleton in *Speotyto* than any other of our Owls, with the exception of *Surnia*. It differs, however, in possessing a well-developed vomer, whereas it lacks the process on the quadratojugal bar seen in the Burrowing Owl. *Megascops* has an extensive internasal septum which is quite thick and extends well backward. The interorbital septum is thin, and may show a small vacuity near its centre. Either superior border is but very slightly rounded off, it being quite sharp in *Speotyto*. Another point wherein these two Owls agree and differ from others is the formation of the foramen in the squamosal region of the cranium, through which the tendon of the temporal muscle passes. This character was described when

speaking above of the same condition as it occurs in *Speotyto*. In *Megascops* the supraorbital processes are very nearly entirely aborted, and in young Burrowing Owls they are not very strongly pronounced. Both forms have symmetrical skulls, and in both the mandibles are almost entirely alike.

With respect to the remainder of the skeleton, a *Megascops* has the four-notched sternum, in front of which the coracoidal grooves do not decussate, and the manubrium is small. The os furcula is a single U-arch and a weak one. At the distal end of the radius in the skeleton of the wing the os prominens is almost of rudimentary proportions. Finally, aside from specific variations in form, all the other components of the representatives of this genus agree with the bubonine type of structure.

Already I have noted the fact above that *Surnia ulula* approaches *Speotyto* closely in some of the characters of its skeleton. This is especially noticeable in the skull, where not only the general contour of that structure in the Hawk Owl strongly reminds one of the skull of *Speotyto*, but we find the resemblance to be real when we come to examine and compare some of the details. For instance, the external narial apertures are subcircular, or we might say broadly elliptical in *Surnia*, just as they are in the Burrowing Owl; and, moreover, we find find the supraorbital processes to be of the same form in each. *Surnia* further has the process on the upper side of the quadrato-jugal bar, although it is not as strongly pronounced as it is in *Speotyto*. Again, *Surnia* lacks a vomer, and the structures at the base of the cranium very closely resemble the corresponding ones in the Burrowing Owl.

In the sqaumosal region, however, the foramen for the passage of the tendon of the temporal muscle does not form as it does in *Speotyto*, there being but a broad notch in the place of it.

The mandibles are very much alike in the two birds; and the remainder of the skeleton in *Surnia* is fashioned upon the type in the bubonine Owls generally.

Lastly, we must say a word about the skeleton in those dwarfs of the Strigine race, the Pygmy and Elf Owls. Personally, I have never examined the skeleton of a *Glaucidium*, but on the other hand I possess three skeletons of *Micropallas whitneyi*, a smaller Owl than any of the pygmies[1] (see Pl. XIV, Figs. 17 and 18).

[1] I am indebted to Mr. Herbert Brown, of Tucson, Arizona, for this valuable

These diminutive birds, so far as we can judge from *Micropallas*, possess a skeleton that has in it many characters that remind us of the skeleton in *Speotyto*. The general form of the skull is much the same, although it will be seen that in *Micropallas* the fronto-supraorbital processes are almost entirely aborted. Both species apparently lack a vomer, while, too, both have the peculiar expansion on the upper side of the quadrato-jugal bone. This is very conspicuous in *Micropallas*, and appears to have something to do with making a more complete bony periphery for the orbit. The sclerotal plates of the eyeball rest against it below. Superiorly, round behind and at the sides, *Micropallas* has an unusually rotund cranium, and shows in the squamosal region a notch for the transmission of the tendon of the temporal muscle. No asymmetry is noticeable in the skull, and the arrangement of the bones of the roof of the mouth are very much as we found them in the Burrowing Owls. A good-sized ramal vacuity exists in either ramus of the mandible and the hyodean apparatus essentially agrees with *Speotyto*. Other points worthy of notice in the skeleton of *Micropallas* are: it has in the arm a pneumatic humerus, and a very small os prominens at the distal end of radius over the wrist. Its os furcula is feeble, but thoroughly united below; the manubrium of the sternum is well pronounced, and the sternum itself four-notched. When *in situ* the coracoids are well apart at their sternal extremities, and the shafts of those bones are each pierced by a foramen, in a manner similar to what we find in so many Hawks and Owls. Its vertebræ and ribs, between skull and pelvis, agree with the bubonine type of Owls generally, but it seems to possess a fewer number of caudal vertebræ, never as many as eight free ones, as we find in other representatives of this group of birds. Another structure we must observe is its pelvis; this differs considerably in pattern from what we see as a rule in most other Owls, for in some respects it reminds me not a little of the pelvis as I have found it in certain Passerine types. In it the pelvic basin is not noticeably contracted nor deep; and what is still more striking, there is no inclination for the post-pubic bones to curve toward each other posteriorly. They project

material, and at the time I received it there was not a skeleton of a *Micropallas* in any of the collections of the larger institutions of the United States nor in Europe. Moreover, I understand, the bird, through the persistent destruction of collectors, stands much in danger of becoming extinct.

directly backward, as do also the ischia above them. Aside from the disproportion we see in the relative lengths of the bones of the leg of *Speotyto, Micropallas* has a skeleton of that extremity much as we find it in those birds. Its fibula is exceedingly slender and considerably shorter than the tibio-tarsus; the arrangement and structure of the podal joints of pes is bubonine.

On the Affinities of the United States Striges.

Regarding the Owls as a whole, the present writer considers them to be a group of nocturnal birds of markedly raptorial habits. Some of the species, however, are largely diurnal in their ways. They are not especially related to the *Accipitres*, but are, on the other hand, remotely allied with the *Caprimulgi*. What we now know of the structure of such forms as *Steatornis* and *Podargus* sufficiently indicate this much.

Taking the Owls in our own avifauna, they may readily be grouped into two well-marked families—the *Strygidæ*, to contain *Strix*, and the *Bubonidæ*, to contain all the other genera. *Strix pratincola* comes nearer the *Caprimulgi* than any other of our Strigine types. This is remotely suggested to us by the form of its sternum, the general aspect of the skull and a few minor points elsewhere in the skeleton. Of all the bubonine Owls we are inclined to think that *Asio wilsonianus* comes nearer *Strix* than any of the others. There is also doubtless an affinity among the genera *Surnia, Speotyto* and *Micropallas*. *Bubo* and *Nyctea* are strong types, with a great raptorial aspect in the cast of their skeletons, more especially in their beetle-browed skulls and their powerful raptorial feet.

Perhaps the asymmetry of the skull may also point to generic affinity, though it is a question; but if so, then *Syrnium, Surnium* and *Nyctala* may be considered more closely related among themselves than they are with any of the other genera.

Megascops approaches *Bubo*, and has a few characters, of light weight, in its skeleton that agree with the corresponding ones in *Speotyto*.

Explanation of Plates.

[The figures in these Plates are all reproductions of photographs made direct from the specimens by the author, represented by material either in his own private collection or in the collections of the U. S. National Museum at Washington, D. C., U. S. A.]

Plate X.

Fig. 1. Basal view of the skull of a nestling Great Horned Owl (*Bubo virginianus*). Mandible articulated, but a number of the bones of vault of cranium and face removed. Maxillaries and maxillo-palatines somewhat displaced. Natural size. Specimen in the author's collection, and taken for him by Dr. W. S. Strode, of Bernadotte, Ill. The nestling was just quitting the nest.

Fig. 2. Basal view of the skull of nestling *Bubo virginianus*. Belonged to the same clutch as the one in Fig. 1, and has the same history. Natural size and shows how these birds vary in the matter of proportions when hatched nearly at the same time. Figs. 1 and 2 show well the sutural lines at the base of the cranium.

Fig. 3. Outer aspect of the right pelvic limb of the nestling *Bubo virginianus*. Natural size, and from the same specimen to which the skull shown in Fig. 2 belonged. This specimen exhibits very well the ossific centres and development of the epiphyses about upper part of the ankle-joint.

Fig. 4. Palmar aspect of the right pectoral limb of the nestling *Bubo virginianus*. Natural size, and from the same specimen to which the skull shown in Fig. 2 belonged, as well as the pelvic limb in Fig. 3. The humerus and distal phalangeal digit are somewhat turned aside from their normal positions.

Plate XI.

Fig. 5. Right half, internal view of the skull of an adult specimen of the Great Horned Owl (*Bubo virginianus*). Natural size and showing comparative proportions of brain cavity, the amount of diploëic tissue and other structures. Mandible removed, but quadrate and pterygoid *in situ*. (Spec. No. 17139, Coll. U. S. Nat. Mus.)

Fig. 6. Left half, internal view of the skull of *Bubo virginianus*. Natural size and from the same specimen as shown in Fig. 5.

Fig. 7. Superior aspect of the skull of an adult specimen of the Great Horned Owl (*Bubo virginianus*). Natural size and the mandible removed. From an unnumbered specimen in the Collection of the U. S. National Museum.

Plate XII.

Fig. 8. Basal view of the skull of an adult specimen of the Snowy Owl (*Nyctea nyctea*). Natural size and with the mandible removed. (Spec. 18458 of the Coll. of the U. S. Nat. Mus.)

Fig. 9. Dorsal aspect of the pelvis and three anterior caudal vertebræ of an adult specimen of the Hawk Owl (*Scotiapex cinerea lapponica*). Natural size and from a specimen in the author's private collection; it having been presented to him by Mr. Ernest Seton-Thompson, who collected it near Toronto, Canada, in May, 1890.

Fig. 10. Left lateral view of the skull and mandible of an adult specimen of the Great Horned Owl (*Bubo virginianus*). Natural size and the same skull as shown in Pl. XI, Fig. 7.

FIG. 11. The ventral aspect of the sixth to the twelfth cervical vertebræ of an adult specimen of the Snowy Owl (*Nyctea nyctea*). Natural size and from the same specimen which furnished the skull shown in Fig. 8. (Coll. U. S. Nat. Mus., No. 18458.)

PLATE XIII.

FIG. 12. Basal aspect of the skull of an adult specimen of the Screech Owl (*Megascops asio*). Natural size, mandible removed, but with the circlets of sclerotals of the eyes left *in situ* in the orbits. When photographed the skull was slightly rotated to the left. (Spec. No. 18987 of the Coll. U. S. Nat. Mus.)

FIG. 13. Superior aspect of the skull of an adult specimen of *Pulsatrix torquato* from Nicaragua. Natural size and mandible removed, which latter is shown in Fig. 15. (Coll. U. S. Nat. Mus., No. 18350.)

FIG. 14. Superior aspect of the skull of an adult specimen of the American Hawk Owl (*Surnia ulula caparoch*). Natural size and mandible removed (in author's private collection).

FIG. 15. Superior aspect of the lower mandible of an adult specimen of *Pulsatrix torquata*. Natural size and from the same specimen which furnished the skull shown in Fig. 13.

FIG. 16. Left lateral view of the trunk skeleton, shoulder-girdle and the femora of a specimen of the Screech Owl (adult), *M. asio*. Natural size, and belonged to the same specimen which furnished the skull shown in Fig. 12. The os furcula is broken near its lower part.

PLATE XIV.

FIG. 17. Left lateral view of the entire skeleton of an adult specimen of the Elf Owl (*Micropallas whitneyi*). (Ligamentous preparation.) Very slightly reduced from a specimen in the author's collection, and presented to him by Mr. Herbert Brown, of Tucson, Arizona (May, 1890). The windpipe is broken and protrudes in front of the cervical vertebræ. The circlet of sclerotal plates are in the left orbit. This is the skeleton of one of the smallest of the existing species of Owls in the world.

FIG. 18. Superior aspect of the skull of an adult specimen of the Elf Owl (*Micropallas whitneyi*). Very slightly reduced and mandible not removed. Another specimen other than the one shown in Fig. 17, but with the same history.

FIG. 19. Left lateral aspect of the skull and mandible of an adult specimen of the Screech Owl (*Megascops asio*). Very slightly reduced and with the sclerotal plates of the left eye *in situ*. Same skull as shown in Plate XIII, Fig. 12.

FIG. 20. Anterior aspect of the sclerotal plates of the right eye of an adult specimen of the Great Horned Owl (*Bubo virginianus*). Very slightly reduced, and from the same skeleton to which the skull belonged shown in Plate XII, Fig. 10.

FIG. 21. Superior aspect of the skull of an adult specimen of the American Barn Owl (*Strix pratincola*). Very slightly reduced. Hyoid arches wired to the skull *in situ*, and this is seen through the left orbit. (Spec. No. 18196 of the Coll. U. S. Nat. Museum, and the same specimen as shown in Plate XV, Fig. 24. Mounted in the cases of the Osteological Department, and kindly loaned by Mr. F. A. Lucas.)

PLATE XV.

FIG. 22. Palmar aspect of the right humerus of an adult specimen of the American Long-eared Owl (*Asio wilsonianus*). Author's collection, and taken by him

at Fort Fetterman, Wyoming, U. S. A., in April, 1881. Natural size, and from the same skeleton to which the parts shown in Fig. 23 and Fig. 30 of Plate XVII belonged.

FIG. 23. Basal aspect of the skull of *Asio wilsonianus*. Natural size, mandible removed (see history in Fig. 22).

FIG. 24. Right lateral aspect of the skull of an adult specimen of the American Barn Owl (*Strix pratincola*). (History given under Plate XIV, Fig. 21, where the same skull is shown on superior view).

FIG. 25. Left lateral view of the trunk skeleton and left femur of the American Barn Owl (*Strix pratincola*). Natural size. Author's private collection, and taken near New Orleans, La. (1883).

PLATE XVI.

FIG. 26. Anconal aspect of the left carpo-metacarpus of the Snowy Owl (*Nyctea nyctea*). From same specimen which furnished the skull in Fig. 8 of Plate XII, and also the humerus and coracoid and scapula of the present plate (Figs. 28 and 29). Somewhat reduced.

FIG. 27. Ventral aspect of the sternum of the American Hawk Owl (*Scotiapex cinerea lapponica*). Somewhat reduced, and from the same skeleton which furnished the pelvis shown in Fig. 9 of Plate XII. A few of the costal ribs have remained attached.

FIG. 28. Palmar aspect of the left humerus of the Snowy Owl (*Nyctea nyctea*). Adult, somewhat reduced (see description of Fig. 26).

FIG. 29. Inner aspect of the left coracoid and scapula, normally articulated, of the Snowy Owl (*Nyctea nyctea*). Somewhat reduced (see descriptions of Figs. 26 and 28).

PLATE XVII.

FIG. 30. Left lateral aspect of the trunk skeleton of the American Long-eared Owl (*Asio wilsonianus*). Natural size, and from the same skeleton that furnished the skull and humerus shown in Figs. 22 and 23 of Plate XV, where the history of the specimen is recorded.

Stated Meeting, December 21, 1900.

Vice-President SELLERS in the Chair.

Present, 18 members.

Donations to the Library were announced and the thanks of the Society ordered therefor.

The report of the Finance Committee was presented.

Nominations for Officers and Councillors were made.

The meeting was adjourned by the presiding officer.

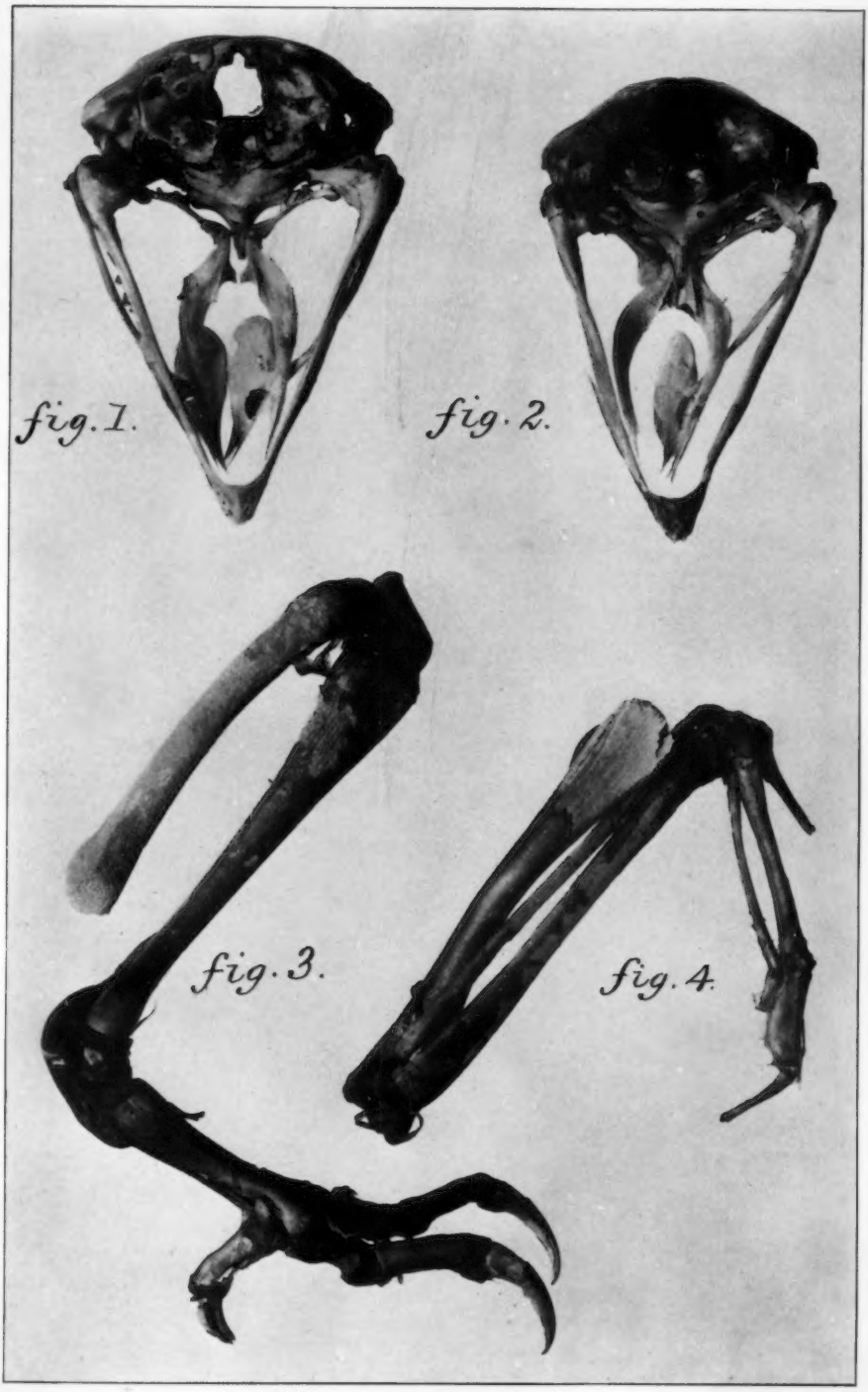


fig. 1.
fig. 2.
fig. 3.
fig. 4.

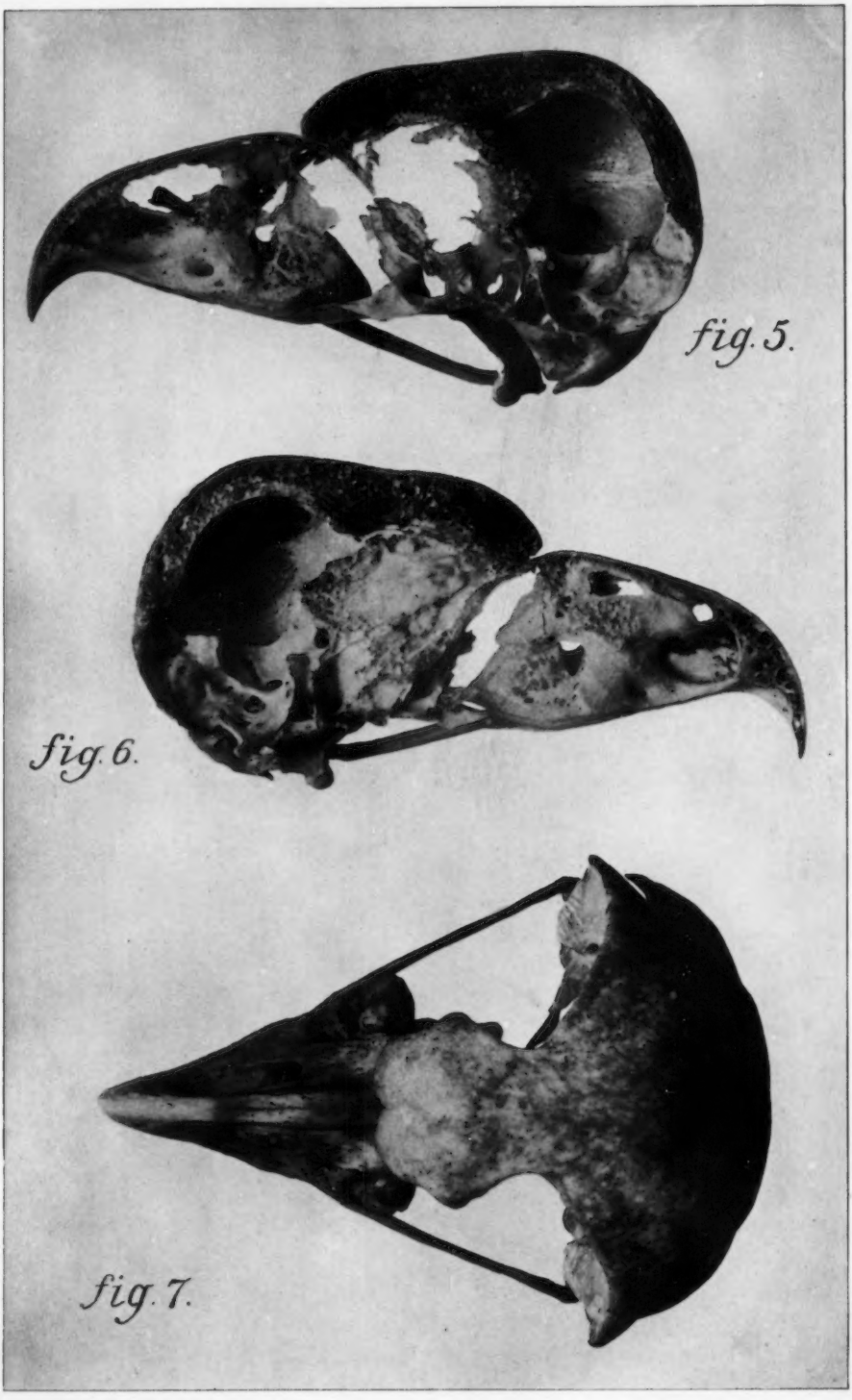


fig. 5.

fig. 6.

fig. 7.

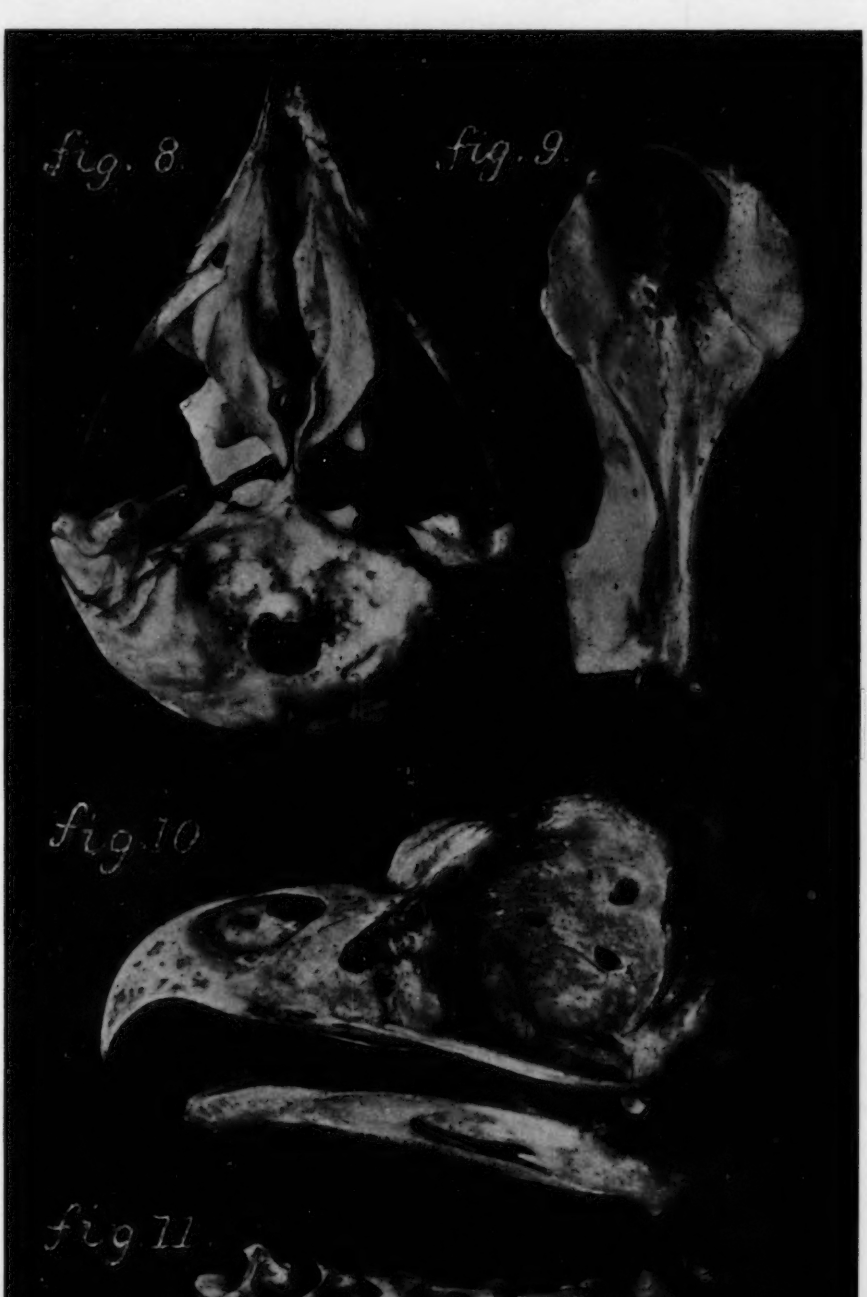


fig. 8.
fig. 9.
fig. 10
fig 11

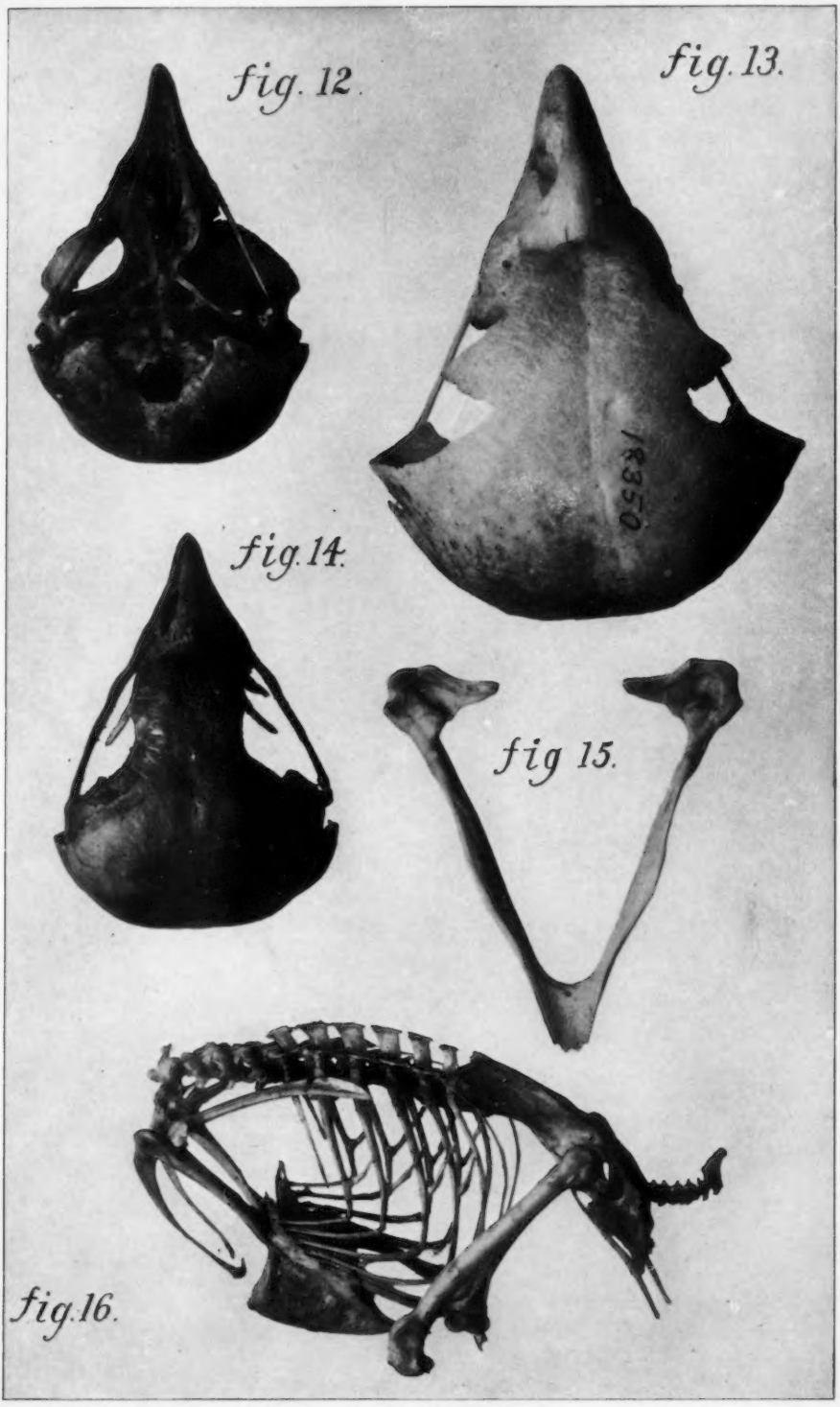


fig. 12.
fig. 13.
fig. 14.
fig 15.
fig. 16.

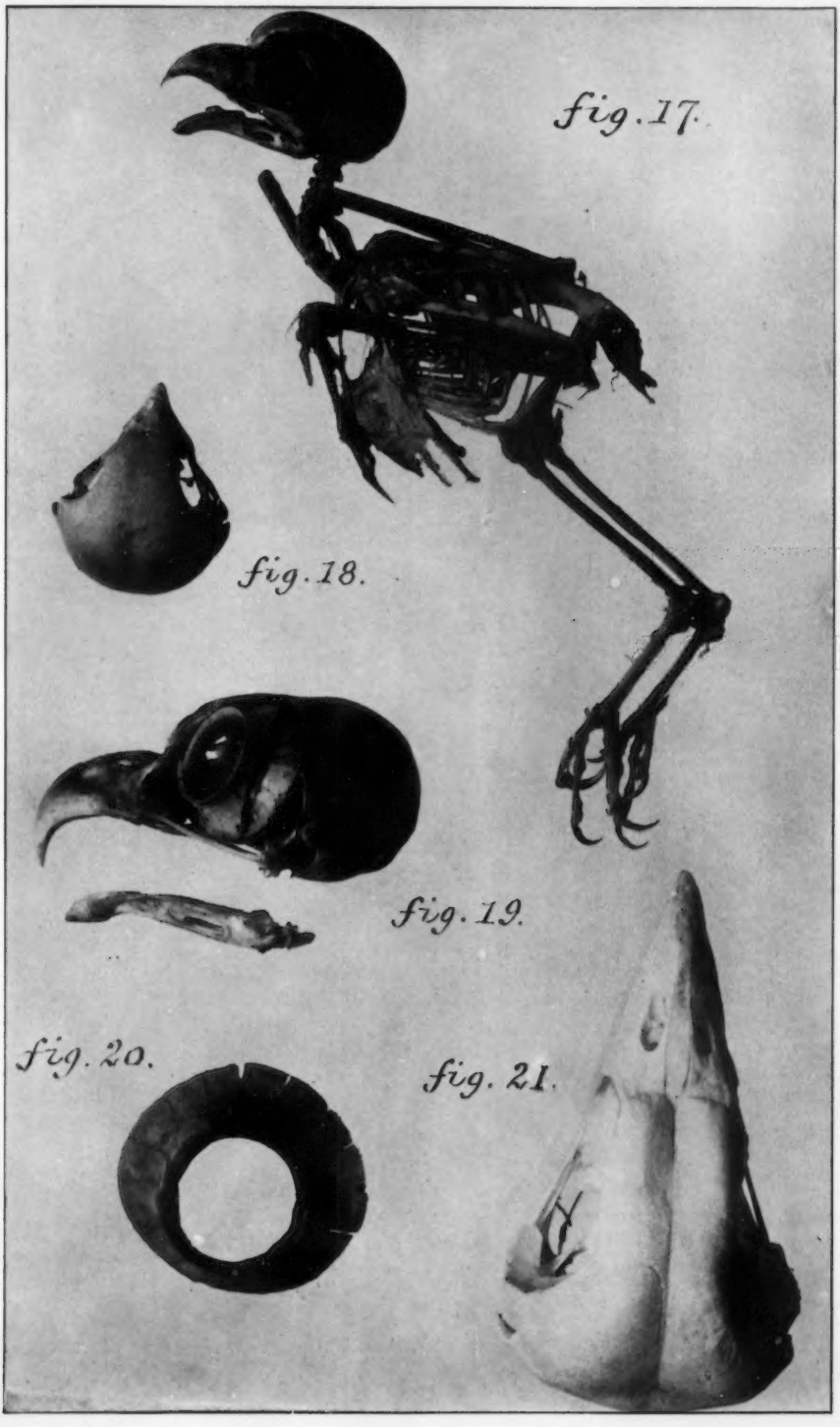


fig. 17.
fig. 18.
fig. 19.
fig. 20.
fig. 21.

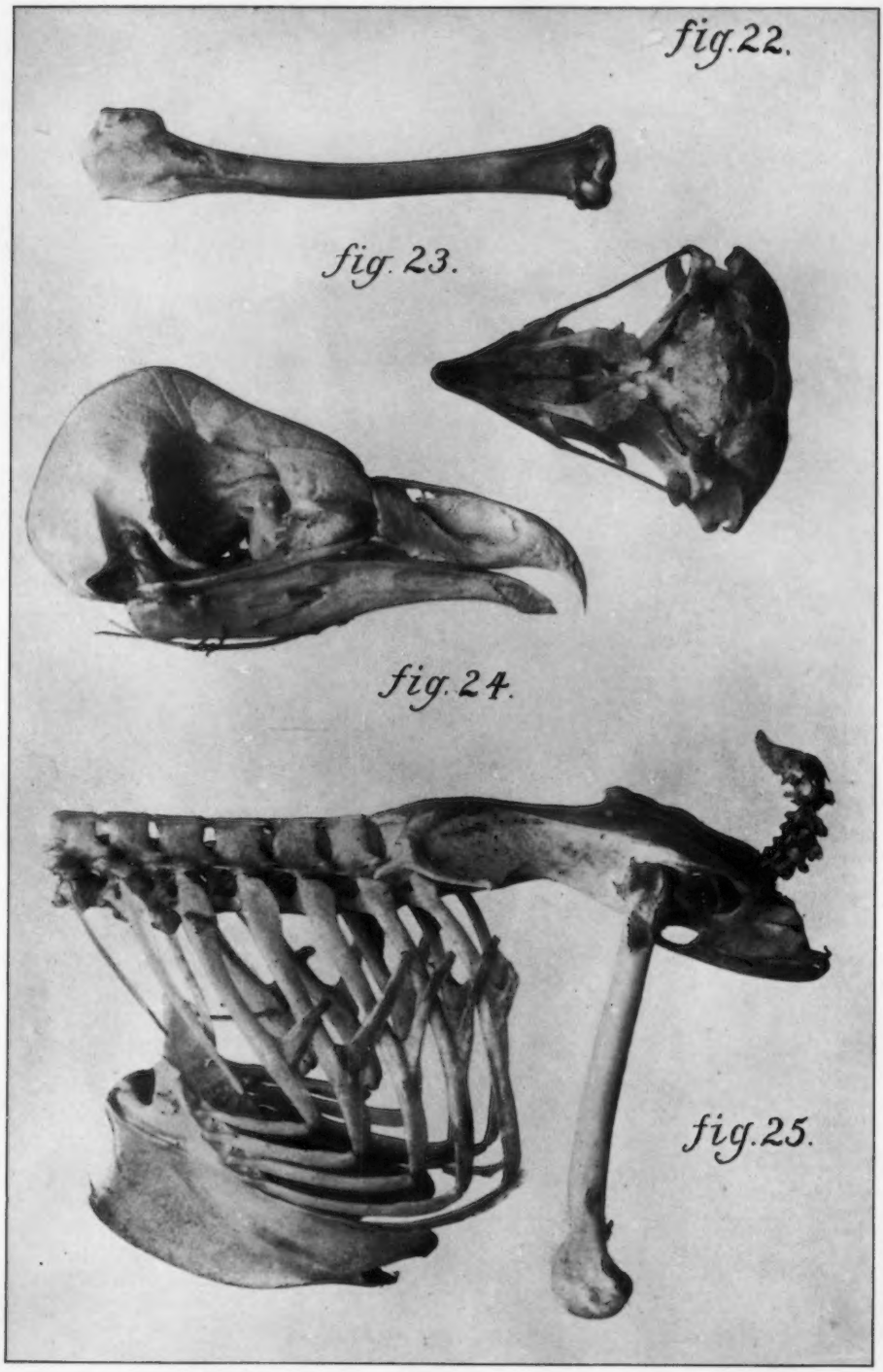


fig. 22.
fig. 23.
fig. 24.
fig. 25.

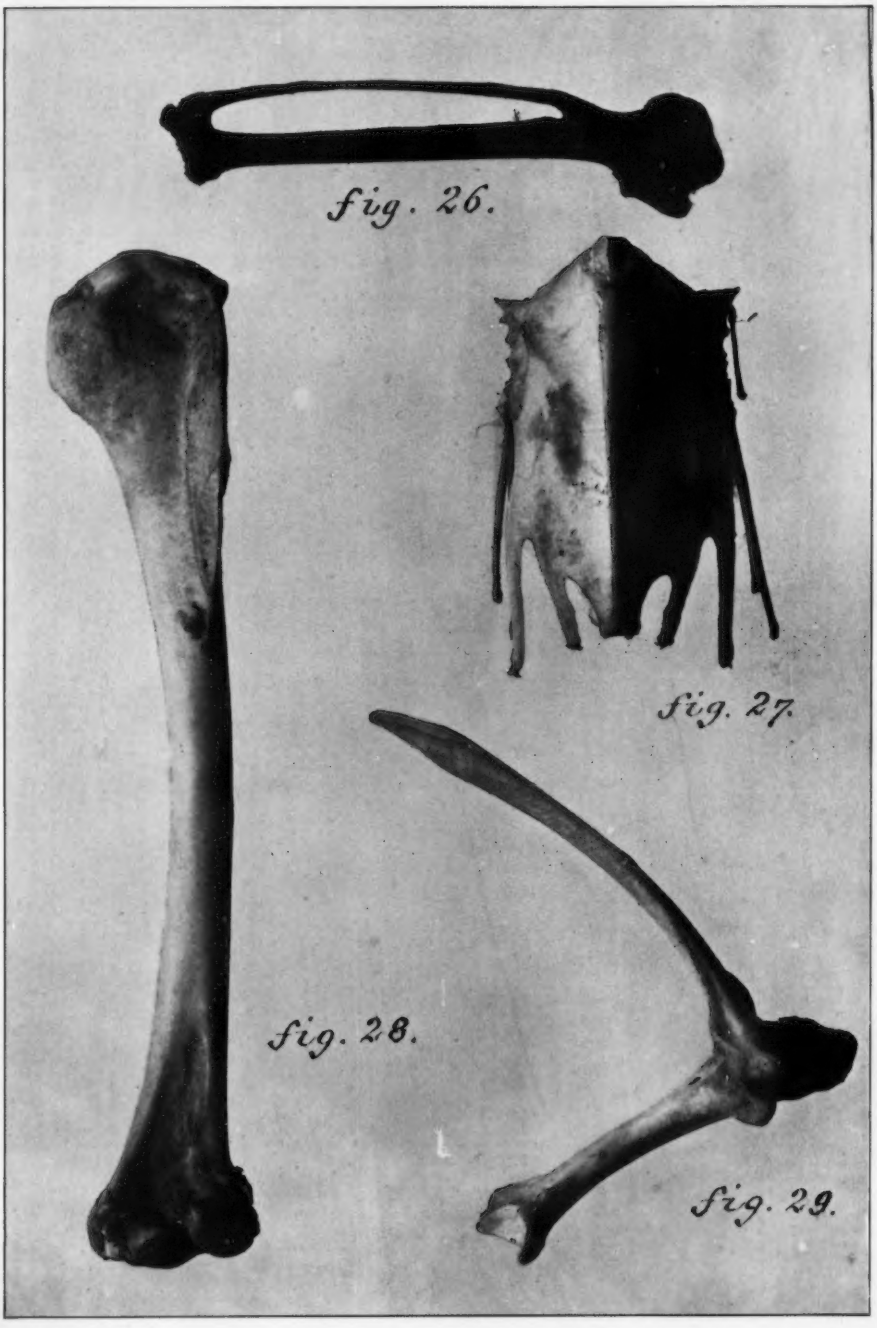


fig. 26.
fig. 27.
fig. 28.
fig. 29.

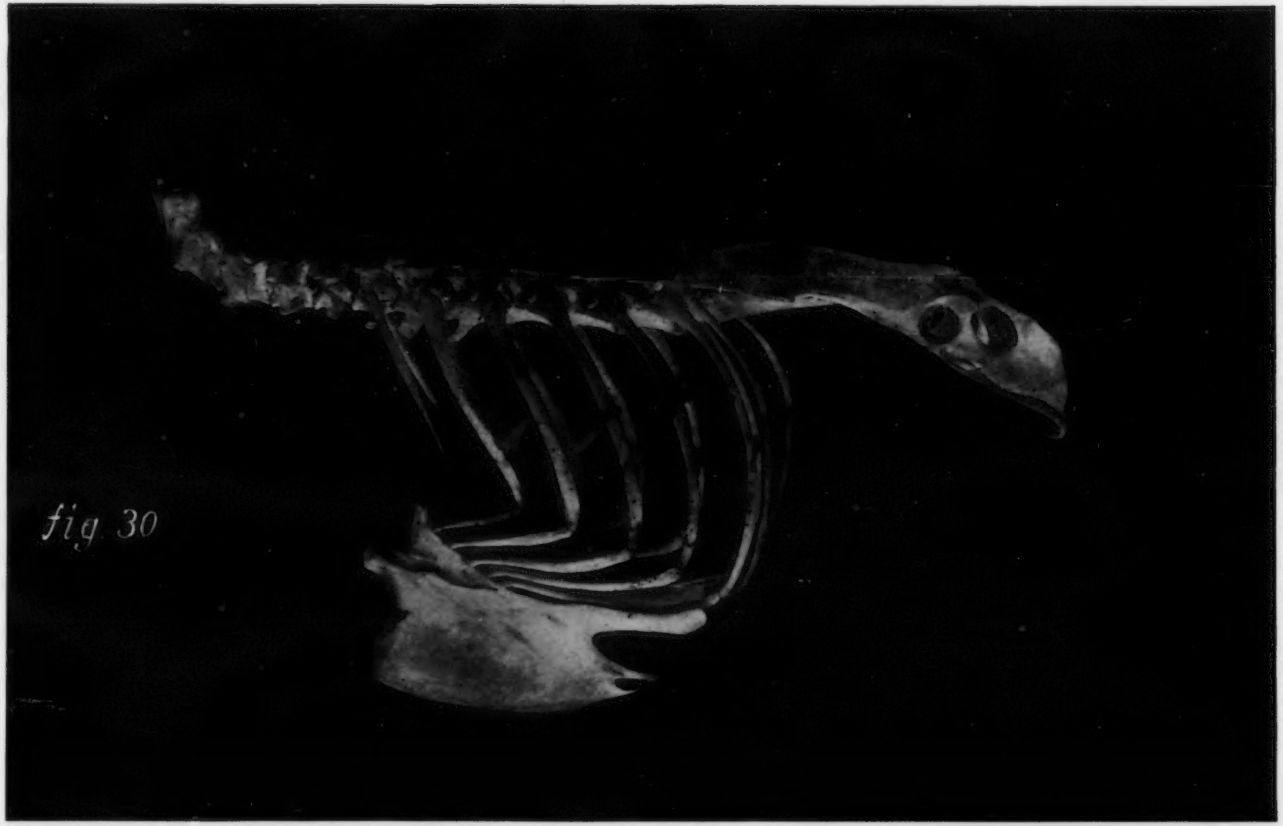


fig 30

OBITUARY NOTICES OF MEMBERS DECEASED.

HENRY HARTSHORNE.—During the decade which closes the nineteenth century there have passed away from our membership alone, to be enrolled among the vast majority, no less than two hundred and eighteen of those whose labors in search of truth and the dissemination of useful knowledge among our fellow-men had rendered them famous in our own or in foreign lands, and whose qualities had endeared many of them individually to those among us who still mourn their loss and feel all the more keenly the burden which they were wont to share with us. Of these men so distinguished in every branch of thought—philosophy, theology, law, medicine, natural science, physics, astronomy, history, archæology, literature, poetry, painting and all the other useful arts and sciences applied for the promotion of the comfort of life and the well-being of the human race—it is not my purpose to-night to speak: nor of the wonderful effect of their labors on the progress of human thought, on our acquaintance with the world in which we dwell, the history of those who have gone before us, our social and civic relations with each other, or even the evolution of a higher manhood. But among these men of higher purpose I would call attention especially to our own personal losses among the resident members of our Society, numbering no less than ninety-eight, whose presence and aid we so sadly miss, as well as that of many others among the non-residents whose more or less frequent visits and communications rendered them almost as well known in this Hall as the resident members. And yet again among these men distinguished as they were in their various avocations, literary, scientific, social or economic, I would especially call to mind those whom I may in a larger sense call our Educators, whether in the lines of original investigation or in those of collaboration and utilization of others' labors or in those of public instruction, whether as lecturers, teachers or writers. Among these the names of Leidy, Le Conte, Horn, Agnew, Genth, Rogers, Furness, Wormley, Pancoast, Gregory, Cope, Traill Green, G. W. Biddle, Sartain, Childs, Harrison Allen, Goodell, Ashhurst, McCosh, Cattell, Rhoads, Coppée, Ruschenberger, Ryder, Keating, Maisch, Parvin, Pepper, Brinton, Kendall and others will doubtless present themselves to your minds. Among these, and as one worthy to be ranked among the foremost,

though his inherent gentleness and modesty, as well as his absence during the latter years of his life, caused him to be less known at our meetings than others, I would place the subject of this obituary notice.

Henry Hartshorne, born March 16, 1823, was the third son of Dr. Joseph Hartshorne, a distinguished physician and surgeon, one of the leading and most successful practitioners of his day—a man of firm character and sturdy common sense, of short thick-set frame supported on somewhat club feet, whose earnestness and honesty impressed every one at first glance. Active and vigorous in mind and body; a rigid follower of the older school, in whose practice blood-letting, purging and low diet had such large part, and yet of reading, culture and broad views sufficient to seize and adopt advances as they were made in therapeutics and science, he gave to his children the best education in accordance with his times and principles which could be had. No time or expense was begrudged in fitting them to take an active, leading and useful part in the great battle of life. In all this he was ably seconded by his lovely wife, Anna, the daughter of Mr. Isaac Bonsall, a real estate lawyer and conveyancer, well known and highly respected. She was a motherly woman of fine intellectual ability and cultivation, and a charming hostess. The family circle was large and agreeable; and under such circumstances were reared men destined to play no small part in their various professions. Henry's eldest brother died early; the second was Edward; Isaac, a younger brother, settled early in life in Western Maryland at Sandy Springs, devoting himself to agricultural pursuits. His brother Edward, after long training at home and abroad, settled in Philadelphia and achieved prominence as a surgeon and oculist and as editor of *The Medical Examiner*, as well as author of many and useful pamphlets and other publications; while his youngest brother Charles was for many years Vice-President and President of the Lehigh Valley Railroad Company, an honored, trusted and useful official.

Henry was educated at Haverford School, now Haverford College, graduating there in 1839; and studied medicine, in accordance rather with his father's wishes than his own desires, at the University of Pennsylvania, graduating in 1845. I may mention that he also received from the latter the degree of A.M. in 1860 and LL.D. in 1884—well-deserved tributes to his merit. He was Resident Physician at the Pennsylvania Hospital until 1848, when he com-

menced the practice of his profession, living at first on Callowhill near Twelfth street; after the decease of his father, at the residence of the latter on Arch below Tenth, and subsequently moving to Arch below Fifteenth. His literary, poetic and artistic tendencies were such, however, as to direct him rather into other fields than those of the general practitioner; he saw enough of these to broaden and ripen his judgment and make valuable his many writings without wasting his force on the mere routine of his profession. He thus early became a teacher rather than a mere practitioner, laboring with voice and pen for the attainment of the high ideals of good for his fellow-man which always inspired him.

Among his professional activities, however, should be noted his services during the epidemics of cholera in Philadelphia in 1849 and Columbia, Pa., in 1854, his observations, reflections and studies resulting in his work on the subject published in 1866; also, his highly valued services during the civil war as surgeon at two of our Government hospitals in this city, and also as volunteer at Gettysburg, after the battle, where I well remember how we greeted his useful, cheerful aid in bringing order out of the chaos into which everything was thrown by the sudden demands for housing and care of more than 20,000 wounded and sick men and prisoners of war.

In 1849 he married Mary E., the daughter of Jeremiah Brown, Esq., of Philadelphia, a lady of great refinement and culture, but unfortunately of rather feeble physical health, the assiduous care of which taxed all the best qualities of his mind and heart. She was in every way worthy of this devotion: and their union was a very happy one, though care and thought for her essentially modified the activities which might otherwise have absorbed his attention. Yet these actually were such as showed him to be no mere ordinary man.

He was Professor of Institutes at the Philadelphia College of Medicine in 1853–54; Prize Essayist at American Medical Association in 1856 (his essay ably supporting views of the muscular activity of the arteries in maintaining the blood-current); wrote numerous articles for medical journals; lectured at the Franklin Institute on various subjects in 1857–58; gave a course of ten lectures on the Natural History of Man, advocating unity of species and origin, as against the views then rising of multiple origin, besides several other courses of lectures. Under these studies and labors

his health suddenly broke down in 1858, when with his wife he went to Europe and passed a year in travel, going also to Egypt and ascending the Nile to Thebes. On his return in the autumn of 1859, he became Professor of Practice of Medicine in the Medical Department of Pennsylvania College, succeeding the brilliant Dr. Alfred Stillé, who was then elected to the University of Pennsylvania. But owing to the outbreak of the War of Rebellion in 1861, which cut off the supply of Southern students, he in common with the other members of the Faculty withdrew. He was Attending Physician to the Protestant Episcopal Hospital, 1860–62; to the Magdalen Asylum, 1849–64, and Consulting Physician to the Women's Hospital, 1868–76. He was also elected, after a *concours* with two competitors, Professor of Anatomy, Physiology and Natural History at the Philadelphia Central High School in 1862; Professor of Physiology and Hygiene at Pennsylvania College of Dental Surgery in 1866; Professor of Diseases of Children, afterward of Physiology and Hygiene and of Diseases of Children at Women's Medical College, 1867–76. He also became Professor of Organic Science and Philosophy at his Alma Mater, Haverford College, in 1868, leaving the High School and Dental College, but retaining his University and Women's College appointments for eight years more. He was also editor of *The Friends' Review*, a religious journal of a high order, from 1873–76, and again from 1881 to 1893. He was also in 1872–73, for a few months, Professor of Natural Science at Girard College. But in the autumn of 1876 he resigned all of his Philadelphia appointments to become the President of Howland School, Union Springs, N. Y., an institution for the higher education of women (a cause which enlisted his deepest sympathies), striving to do for it what Arnold did for Rugby.

The Howland School, however, was not a success, owing to insufficiency of an endowment fund, so that it was closed by the trustees in 1878; when Prof. Hartshorne returned to Philadelphia, settling in Germantown and opening a family school for girls, and continuing the work begun at Howland School. He was reappointed to the chair of Philosophy at Haverford in 1887, but resigned soon after on account of inconvenience in the conditions of fulfilling his appointment.

Besides the above, he was Recorder of the Biological and Microscopical Department of the Academy of Natural Sciences in

1857–58, Dr. Leidy being then its Director; Secretary of Pennsylvania State Medical Society in 1858; Secretary of Section B of the American Association of Science in 1870; one of the founders of the American Public Health Association in 1872, and its Vice-President in 1875–76; member of the College of Physicians, of the Philadelphia Clinical Society, Contemporary Club, Science and Art Club, Browning Society, etc., etc.

He became a member of the American Philosophical Society in 1863, and contributed at least five papers to its PROCEEDINGS; among them one on *Organic Physics*, in 1872, very remarkable for its close reasoning and advanced thought, and another on *Some Disputed Points in Physiological Optics*, explaining complementary color spectra by interference, rather than by fatigue; also paper on *Extuition and Intuition*, approved by Dr. McCosh.

In addition to all these varied activities he was a prolific writer and worker in the various fields of philanthropy, physiology, hygiene, literature, botany, natural science, medicine, theology and pure philosophy, as a glance at his appended bibliography will show. He followed closely inductive methods of thought and expressed himself always with classic purity, neatness and exactness; as instances may be given his introduction and employment of the term "extuition" as an equally certain and correlated source of our knowledge with "intuition," commended by Dr. McCosh, and of the term "autoplanatic" to describe the mode of dissemination of cholera. In his writings on the latter, and also on quarantine as protective against cholera and yellow fever, he long ago took ground now held by the bacteriologists of to-day. So in his signed contributions to Johnson's *Cyclopædia*, that on Evolution is an elaborate historical account and analysis of the different theories of development, ending with adoption of the theory of Theistic Evolution. (This antedates Huxley's article in *Encyclopædia Britannica.*)

So again we find him emphatically among the leaders and pioneers in the work of *Higher Education for Women and Co-education of the Sexes;* while his bold and caustic criticism on the modern treatment of pneumonia and other acute diseases, as read before the College of Physicians and published in their *Transactions* in 1888, shows that he was not afraid or ashamed to speak the whole truth when needful.

Yet with all his power of logic, wit, raillery and pungent, poig-

nant repartee and playful irony, he was never a controversialist. No one ever succeeded in drawing him into a personal dispute, and his charity was of the nature that "thinketh no evil." So it may well be said of him that among all his writings "nihil tetigit quod non ornavit," and that "dying he left no line he need wish to blot."

From Dr. James Darrach's masterly and excellent biographical sketch of Dr. Hartshorne, read before the College of Physicians, June 2, 1897, and from memoranda also most kindly furnished by his daughter, who accompanied her father to Japan, I have drawn up this account of our late friend, and to Miss Hartshorne I am also largely indebted for the approximately complete bibliography which follows.

His poems, while not marked by lofty flights of ambition, excel in purity of thought and elegance of diction. They have a flavor all their own, and hence will find fullest appreciation among kindred minds and spirits, especially those who may know what the higher school of Quakerism stands for. It is pleasant to think that among these appreciative minds, as shown by their letters to him, were such different men and accomplished critics as John G. Whittier, E. C. Stedman and Oliver Wendell Holmes.

His most useful works, and I may add profitable in a pecuniary sense, were treatises and compendiums of practical medicine for the use of students and families. Many of these ran through numerous editions, some of them having also been translated into Japanese and proving highly successful among the efforts made to plant Western learning in the far Orient.

Some of his active interests were displayed also in humanitarian questions arising out of slavery and the civil war, etc., such as the Freedmen's Association, the Institute for Colored Youth (of which he was a Manager), the Indian Rights Association (of whose Executive Committee he was for many years a member), and with the Education of Feeble-minded Children as Manager of the Training School at Elwyn, and with those affecting public health, water supply, milk supply, etc., or with education in general, as Manager of Haverford College or of Friends' Select School, or as Overseer of the public schools, Director of Penn Charter School, etc.

Intellectually he always reminded me of a Damascus blade, with his keen, polished wit and imperturbable good humor, bending

gracefully before a blow, but recovering always his form and delivering though playfully replies whose keen logic and aptitude disposed often of an antagonist as effectually and often as unconsciously to the victim as the fabled sword of Saladin could have done.

In 1886 he was called upon to part from his beloved wife. He continued, however, laboring calmly and steadily in the paths of literary labor and beneficent activity as long as his health and strength permitted.

In 1893, accompanied by his youngest daughter, he went to Japan, where he engaged actively in philanthropic work in connection with the prevention of the opium traffic to Formosa, the work of the Women's Christian Temperance Union and the activities organized under the influence of the Society of Friends.

In this work he was enabled to accomplish much, as his fame and position there had been already established as the author of useful works on medicine, translated and published by Keuvada at Tokio, and used as text-books.

In 1894 he returned home for a short time, but soon again departed in 1895 for this far-off field, where he studied the hospitals at Tokio and elsewhere in the empire, among them two for lepers; and practiced considerably among the missionaries, especially in consultation. During two summers at Sapporo, northern Japan, he had much pleasant intercourse with professors and students of the Imperial College of Agriculture, members of the medical society and missionaries and others summering there.

There he lived and there he died, February 10, 1897, peacefully, after a short illness of only two days.

The appreciation of his work by those among whom and for whom he thus labored may be best shown by the following notice which appeared in the *Japan Mail* of February 12, 1897 :

Funeral of Dr. Hartshorne.

The funeral services of the late Henry Hartshorne, M.D., LL.D., of Philadelphia, Penn., U. S. A., were held on Thursday, February 11, in the meeting-house of the Friends' Mission in Mita, Shiba District, Tōkyō. They were marked throughout by a very impressive simplicity and repose, quite in accord with the expressed desire of the deceased. The building was filled with friends, Japanese and foreign, old and young, missionaries and merchants, teachers and students, who united to pay

their last respects to the dead. The commingling of so many different kinds of people gave evidence of the wide circle of the deceased's acquaintanceship and influence.

None knew him but to love him,
Nor named him but to praise.

The exercises were conducted by Mr. Joseph Cosand, of the Friends' Mission, in a very quiet and calm manner which made a deep impression; and consisted of an appropriate intermingling of English and Japanese. Two of Dr. Hartshorne's favorite hymns, "Jesus, Lover of my Soul," and "More Love to Thee, O Christ," and two Japanese hymns were sung. The opening prayer and the benediction were in Japanese by Mr. Mizuno, of the Friends' Mission; the closing prayer was by Rev. A. A. Bennett, of Yokohama, who was a pupil of Dr. Hartshorne in the Philadelphia High School more than thirty years ago. Two excellent addresses were delivered; one, in English, by Rev. B. Chappell, of Tōkyō, and the other, in Japanese, by Rev. G. F. Verbeck, D.D., of Tōkyō. Both emphasized the lovable and deeply spiritual nature of the deceased.

A large number of friends, both Japanese and foreign, attended the interment at Aoyama Cemetery. The body was carried from the hearse to the grave by foreigners and Japanese. The last prayer was offered by the Rev. Julius Soper, D.D., of Tōkyō. When the coffin had been lowered into the grave, it was covered with flowers and evergreens.

Two years ago, after his first visit to Japan, and when a second one was in mind, Dr. Hartshorne wrote a poem expressive of his desire to be buried in Aoyama. He always preferred, however, to think of Aoyama not as "Green Hill," but as "Hill of Love" (Ai-no-yama). This poem reads as follows:—

AOYAMA.

Beyond the crowded city's utmost reach,
Near but to hospital and college halls,
Where on the ear no sound repellant falls,
Only sweet bell-tones, or soft Nippon speech;
Where moss-grown tombstones their weird sermons preach,
With silent liturgies of attendant trees,
Stirred now and then to whispers by a breeze;
Where all things "man is mortal" gently teach:
Are we not farthest there from all the din,
Ofttimes discordant, of the haunts of men,
Where love and joy are fain to enter in,
Yet strife and sorrow come and come again?
When, on this earth, I make my last remove,
Be it to Aoyama, Hill of Love.

H. HARTSHORNE.

Written in anticipation, Germantown, Pa.,
8 mo. 15, 1895.

As a writer of pure, excellent English he was unexcelled; as a thinker clear, deep and far-reaching; as an investigator calm, impartial and accurate; as a leader in the advancing thought of his day, he was "primus inter pares, facile princeps"—beloved and respected by all who knew him, an active, amiable, gentlemanly Christian—a true Philosopher. And as such we mourn his loss.

Among papers left by him were found memoranda on *Philological Relation of Roots of Japanese Language with Those of Aryan* for a paper which he intended to prepare for A. P. S.; also others on the *Ethnology of Japanese Islands*. It is to be hoped these will find fitting editors.

Bibliography.

Water *vs.* Hydropathy. Thesis at Graduation, 1845. Published 1847. See note Trans. College of Physicians, Vol. ii, N. S., p. 297.

Alma Mater. Poem published by Haverford College Alumni, 1848.

Rupture of Gall Bladder. Trans. College of Physicians, Vol. i, p. 115.

Hospital Cases. Several Series. In Am. Jour. Med. Science, 1849–50.

Influence of Ether on Nervous System. Trans. College of Physicians, 1849–50, Vol. ii, p. 331.

Internal Use of Chloroform, Experiments with, 1849. Trans. College of Physicians.

Cholera Outbreak on Ship *Tonawanda*, 1840. Trans. College of Physicians, Vol. ii, p. 264.

On Meningitis, 1849. Trans. College of Physicians, Vol. ii, p. 342.

Effects of Copper Boilers on Contained Water, 1849. Trans. College of Physicians, Vol. ii, p. 412.

Mode of Treating Fracture of the Thigh, 1849. Trans. College of Physicians, Vol. ii, p. 441.

"Woman's Witchcraft; or, The Curse of Coquetry," a dramatic romance, by Corinne L'Estrange, 1854.

Essay on Arterial Circulation. Prize Essay. American Medical Association, 1856.

Animal Decomposition the Chief Cause of Cholera. *Medical Examiner*, August, 1855.

Valedictory Lecture to Graduating Class, Philadelphia College of Medicine, 1856.

Tendencies of Modern Science (very thoughtful and philosophic). Published in 1856.

Introductory Lecture on Medical Education, Philadelphia College of Medicine, 1857.

Medical Record for Private Medical Statistics, under sanction of Medical Society State of Pennsylvania and Biol. Dept. A. N. S., 1859.

Enlargement of Thymus Gland, Trans. College of Physicians, N. S., Vol. iii, p. 142.

Apparatus for Fracture of Thigh, Trans. College of Physicians, N. S., Vol. iii, pp. 222–249.

Case of Cold Stroke, Trans. College of Physicians, N. S., Vol. iii, p. 339.

Ring Pessaries, Trans. College of Physicians, N. S., Vol. iii, p. 400.

Review of Medical Statistics of U. S. Army, Am. Jour. Med. Science, 1857.

Review of Nott & Gliddon's Indigenous Races, Am. Jour. Med. Science, 1857.

Review of Meryon's History of Medicine, Am. Jour. Med. Science, 1857.

Review of Todd on Acute Diseases, Am. Jour. Med. Science, 1857.

Review of Hammond's Hygiene, Am. Jour. Med. Science, 1857.

Review of DaCosta's Medical Diagnosis, Am. Jour. Med. Science, 1857.

Memoranda Medica, a Notebook of Medical Principles, being a Synopsis of Lectures at Pennsylvania College, 1860.

Facts and Conclusions Upon Cholera. Lippincott, 1866.

Speculative and Inductive Medicine: Introductory Lecture, Medical Department Pennsylvania College, 1860.

Articles (signed) contributed to Johnson's New Illustrated Cyclopædia on Anatomy, Atonement, Brain, Breast, Carbonic Acid, Charcoal, Chess, Chest, Circulation (of blood), Deaf Mutes, Ear, Evolution, Philosophy.

Cardiac Exhaustion in Soldiers, Trans. College of Physicians, 1863.

A Month on the Nile (lecture on Egypt), 1860: Revised and delivered for Science and Art Club, Germantown, 1893.

Summer Songs, a volume of poems, 1865.

Romance of Quaker History (a lecture), 1867.

Monograph on Glycerine. Lippincott, 1865.

Essentials of Principles and Practice of Medicine: Handbook of Human Anatomy and Physiology. H. C. Lea, 1867. Fifth edition stereotyped 1881, and translated into Japanese and published in Tokio, 1875 (over 25,000 copies sold).

Conspectus of Medical Sciences, 1869. Translated into Japanese and published in Tokio.

Family Guide to the Medicine Chest, Lippincott, 1869.

Watson's Practice of Medicine, edited with additions, 1874.

Valedictory to Twentieth Graduating Class, Women's Medical College, 1872.

Some Disputed Points in Physiological Optics, Women's Medical College, 1872.

Present Condition of Vaso-Motor Physiology, American Medical Association, 1872.

Memoir of Edward Rhoads, Proc. Am. Philo. Soc.

What to do Against Yellow Fever, American Public Health Association, 1873.

On Some Disputed Points in Physiological Optics, Proc. Am. Philo. Soc., 1876, Vol. xvi, p. 218.

On Extuition as Source of Knowledge Equivalent with Intuition and Correlation, Proc. Am. Philo. Soc., 1876, Vol. xvi.

On Ocular Spectra and Their Causation, Proc. Am. Philo. Soc., 1876, Vol. xvi, and Am. Jour. Med. Science.

On Theory of Erect Vision with Inverted Images, Jour. of Franklin Institute, 1878.

Theoretic Explanation of Frauenhofer's Lines, 1878.

Reynolds' System of Medicine, edited with additions and illustrations, 1880.

Memoir of George B. Wood, Proc. Am. Philo. Soc., 1880.

Our Homes, American Health Primer, Blakiston, 1880.

Old Founder's Hall—a Poem—Haverford Alumni, 1880.

Bertram the Prince: an Idyll, 1886. Republished with other poems in 1892.

A Bundle of Sonnets. Porter & Coates, 1886.

Our Water Supply. A lecture published by Citizens' Committee, 1889.

Memoir of Edward Hartshorne, Trans. College of Physicians, 3d series, Vol. ix, p. 225, 1886.

The Old and the New Physic, Trans. College of Physicians, 3d series, Vol. ix, p. 387, 1887.

Memoir of James E. Rhoads, Proc. Am. Philo. Soc.

On Vigor and Sex, American Society for Advancement of Science, 1881.

"Glances at the Twentieth Century, 1931." Claxton & Co., 1881.

"Watching for Dawn," *Lippincott's Magazine.*

"To-day," *Lippincott's Magazine.*

Editorials and poems in *Friends' Review and Quarterly.*

"Life's Secret," in *Penn Monthly.*

Sonnet to Matthew Arnold, in *The Critic.*

Medical Ethics, a lecture published in *Medical News*, 1885.

"Lethean Leaves," for private distribution, 1898.

Cholera and Its Migrations, Philadelphia *Medical News*, September, 1892; also in Tokio *Medical Journal*, 1894.

Pneumonia: Its Mortality and Treatment, Trans. College of Physicians, 3d series, Vol. x, pp. 151–189, 1888.

Contraction of Heart, Trans. College of Physicians, 3d series, Vol. xii, p. 152, 1890; Vol. xiii, p. 110, 1891.

Aims and Methods in Education, Teachers' Institute, Salem, N. J., 1870.

Womanhood. Philadelphia Evening Hour Course, 1871: also Sandy Spring, Md., 1886; Germantown Evening Hour Club, 1886, and Lake Mohonk, 1890.

Address to Evangelical Friends in America, 1883.
"Wit, Humor and the Ridiculous," 1870.
Four Lectures on Hygiene, Franklin Institute, 1881.
"Why Few Live to Grow Old," Franklin Institute, 1883.
Quakerism as Factor in Religious and Social World, 1895.
Christianity and Phases of Modern Thought. Tokio Lecture Association, Methodist Publishing House, Tokio, 1896.
Address to Physicians in Japan, at reception by Tokio Medical Society, 1894.

J. CHESTON MORRIS.

INDEX.

Page

American History from German Archives 129, 638
Andalusite, Specimen of 94
Anderson, Col. William, Remarks on 68
Australian Aborigines, Origin, Organization and Ceremonies of the 555, 556, 622
South., divisions of. 68, 78
Western, native tribes of. 94, 96, 123
Barker, George F., Annual Discourse 94
Brinton, D. G., Portrait and Medal of. 68
Buti, Rudolph, Seal of the King Brunaburgas of Babilony 127
Calendar of the Correspondence of Major-General Nathanael Greene 128, 154
Carson, Hampton L., Appointed to Prepare Obituary of William M. Tilghman 345
Committees, Standing, for 1900 69
Conklin, Edwin Grant, Elected Councillor 640
Declaration of Independence, A Contribution to the Bibliography of the 69
Discourse, Annual. 94
Election of Officers, Annual 4
Field, Robert Paterson, Remarks on Col. William Anderson 68
Franklin, Benjamin, Autograph Letter of, to Samuel Huntingdon 95
German Archives, American History from 129, 638
Gortyna and Allied Genera, Historical Sketch of 346
Greene, Major-General Nathanael, Calendar of the Correspondence of. 128, 154
Grote, A. Radcliffe, The Descent of the Pierids 4
Historical Sketch of Gortyna and Allied Genera 346
Hartshorne, Obituary Notice of Henry 1
Hastings, W. G., The Development of Law as Illustrated by the Decisions Relating to the Police Power of the State. 359
Henry M. Phillips Prize Awarded to 358
Hay, O. P., Descriptions of Some Vertebrates of the Carboniferous Age. 96
Hays. I. Minis, A Contribution to the Bibliography of the Declaration of Independence 69
History, American, from German Archives. 129, 638
Huntingdon, Samuel, Autograph Letter of Benjamin Franklin to 95
K. K. Geologische Reichsanstalt of Vienna, Invitation to its Fiftieth Anniversary. . . 357
Karoly, Electricity 555
Kohler, Max I., Honorable Mention of Essay on Police Power of the State 358
Law, Development of, as Illustrated by the Decisions Relating to the Police Power of the State, The 359
Legacy Tax, Committee on Modification of Federal 127
Leidy, Dr. Joseph, Portrait of 94
Leland, Charles G., The Old Mill in Newport 555
Librarian Elected 68
Lowell, Percival, Mars on Glacial Epochs. 641
Mars on Glacial Epochs. 641

Page

Mathews, R. H., Divisions of the South Australian Aborigines 68, 78, 622
Native Tribes of Western Australia 94, 96, 123
Origin, Organization and Ceremonies of the Australian Aborigines . . . 555, 556
Phallic Rites and Initiation Ceremonies of the South Australian Aborigines 555, 622
Medal Struck in Honor of D. G. Brinton 68
Medal Struck in Honor of Sir George Stokes 95
Meetings, Adjourned Stated 69
Special 358
Stated 3, 68, 94, 95, 127, 345, 357, 358, 555, 638, 640

Members Deceased:
Acland, Sir Henry W 638
Argyll, Duke of 346
Ashhurst, John, Jr 555
Bullock, Charles 127
Coues, Elliott 3
Cushing, Frank Hamilton 345
DaCosta, J. M 555
Green, William Henry 94
Greene, S. Dana 94
Hammond, William A 94
von Hauer, Franz Ritter 127
Jannet, Claudio 555
Lawes, Sir John Bennett 555
Leonard, James Biddle 555
Max-Müller, Rt. Hon. Friedrich 640
Paget, Sir James 3
Platt, Franklin 555
Rogers, Fairman 555
Squibb, Edward R 640
Stallo, Hon. John B 94
Tilghman, William M 127

Members Elected:
Adler, Cyrus 357
Gray, Hon. George 357
Keller, H. F 357
Morton, Thomas George 94
Patterson, Hon. Edward 357
Sinkler, Wharton 357
Wright, William Aldis 94

Members Presented to the Chair 3, 68, 95, 127, 640
Membership Accepted 3, 68, 95, 345, 555, 640
Declined 127
Morris, J. C., Obituary Notice of Henry Hartshorne i
Newport, Old Mill in 555
Obituaries Ordered:
Bullock, Charles 345
Tilghman, William M 345
Obituary Notices i
Phallic Rites and Initiation Ceremonies of the South Australian Aborigines . . . 555, 622
Phillips Prize Essay 358, 359, 554
Report of Judges of Award of the 358
Pierids, The Descent of the 4
Police Power of the State, Development of Law as Illustrated by Decisions Relating to 359
Rosengarten, J. G., American History from German Archives 129, 638

Page

Royal Saxon Antiquarian Society of Dresden, Invitation to its Seventy-fifth Anniversary 357
Seal of the King Brunaburgas of Babilony 127
Sellers, Coleman, Carbide of Calcium and Caustic Soda. 345
Shufeldt, R. W., Osteology of the Striges 665
Osteology of the Woodpeckers 555, 578
South Australian Aborigines, Divisions of the 68, 78
Phallic Rites and Initiation Ceremonies of the 555, 622
Standard's Bureau, National. 128, 345
Stokes, Sir George, Medal Struck in Honor of. 95
Striges, Osteology of the. 665
Vertebrates of Carboniferous Age, Description of Some. 96
Washington, Gen., Photograph of a Portrait of. 68
Western Australia, Native Tribes of 94, 96, 123
Woodpeckers, Osteology of the 555, 578